THE ENGLISH AND AMERICAN MECHANIC:

AN EVERY-DAY HAND-BOOK FOR THE WORKSHOP AND THE FACTORY.

CONTAINING SEVERAL THOUSAND RECEIPTS, RULES AND TABLES INDISPENSABLE TO THE MECHANIC, THE ARTISAN AND THE MANUFACTURER.

BY

B. FRANK VAN CLEVE.

A NEW, REVISED, ENLARGED AND IMPROVED EDITION

EDITED BY

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ILLUSTRATED BY EIGHTY-FIVE ENGRAVINGS.

PHILADELPHIA:
HENRY CAREY BAIRD & CO.,
INDUSTRIAL PUBLISHERS, BOOKSELLERS AND IMPORTERS,
810 WALNUT STREET.
LONDON:
E. & F. N SPON, 125 STRAND.
1890.

PRINTED AT
COLLINS PRINTING HOUSE,
PHILADELPHIA, U. S. A.

PREFACE.

THE purpose of the ENGLISH AND AMERICAN MECHANIC is to serve as a handy reference book for the manufacturer, and to supply the intelligent workman with information required to conduct a process foreign, perhaps, to his habitual labor, but which at the time it may be necessary to practice. In order effectually to do this and to supply the reader with the most recent information on the various subjects treated of, it was determined to issue a new, enlarged and improved edition, which, it is hoped, will render the volume still more useful in the future than it has been in the past, great as has been its success and popularity.

Self-help seems to be the guiding spirit of the present age, and there is a growing demand for handy practical books containing the necessary hints and instructions without enlarging on the theories and principles, or discussing the historical stages of the particular art or industry under consideration, and the aim of the present edition is to give reliable information in as concise a form as possible.

No person who has not undertaken the labor of referring to the numerous volumes, journals and transactions of societies devoted to technical subjects now published in Europe and America, can form an adequate idea of the amount of research involved in the compilation of a work of this character, giving the results of the investigations and experiments of so many indefatigable laborers. The editor has endeavored to select only the best processes and receipts, which have been verified by competent authorities, and the aim throughout has been to render the ENGLISH AND AMERICAN MECHANIC a reliable

hand-book for all interested in technological pursuits. It is, in fact, an *Encyclopædia of Useful Technical Knowledge*, its pages presenting an array of information indispensable not only to the practical manufacturer and mechanic, but also to the amateur workman.

In regard to the various receipts for mechanical purposes, it is well to remember that to the individual skill of the workman in performing many apparently simple operations is success due; and that this skill is only obtained by long practice or natural ability. When, therefore, a receipt is for the first time tried, and it is not thoroughly successful, the experimenter should consider how far his own inexperience has contributed to the failure before he condemns the receipt. In using the receipts the observance of the following rules is recommended: 1. Be careful to use the exact proportions prescribed. 2. Always experiment first with small quantities.

The editor acknowledges his indebtedness to numerous English and American authors for valuable material, for tables, etc., and takes pleasure in expressing his obligations to the enterprising publishers for the assistance rendered to him by a liberal supply of books and journals.

A very copious table of contents, as well as an index, will render reference to any subject or special receipt prompt and easy.

EMORY EDWARDS.

June 10, 1890.

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THE

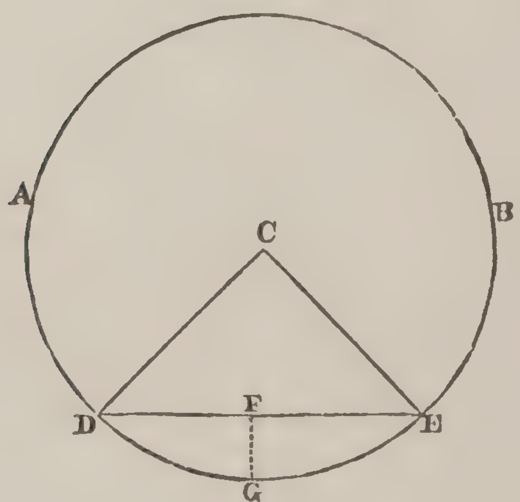
AMERICAN AND ENGLISH MECHANIC.

Part I.

EXPLANATION OF DIAGRAMS.

To find the Circumference of any Diameter.

Fig. 1.



From the centre C describe a circle A B, having the required diameter; then place the corner of the square at the centre C, and draw the lines C D and C E; then draw the chord D E: three times the diameter added to the distance from the middle of the chord D F E to the middle of the subtending arc D G E, will be the circumference sought.

To find the Area of the Sector of a Circle.

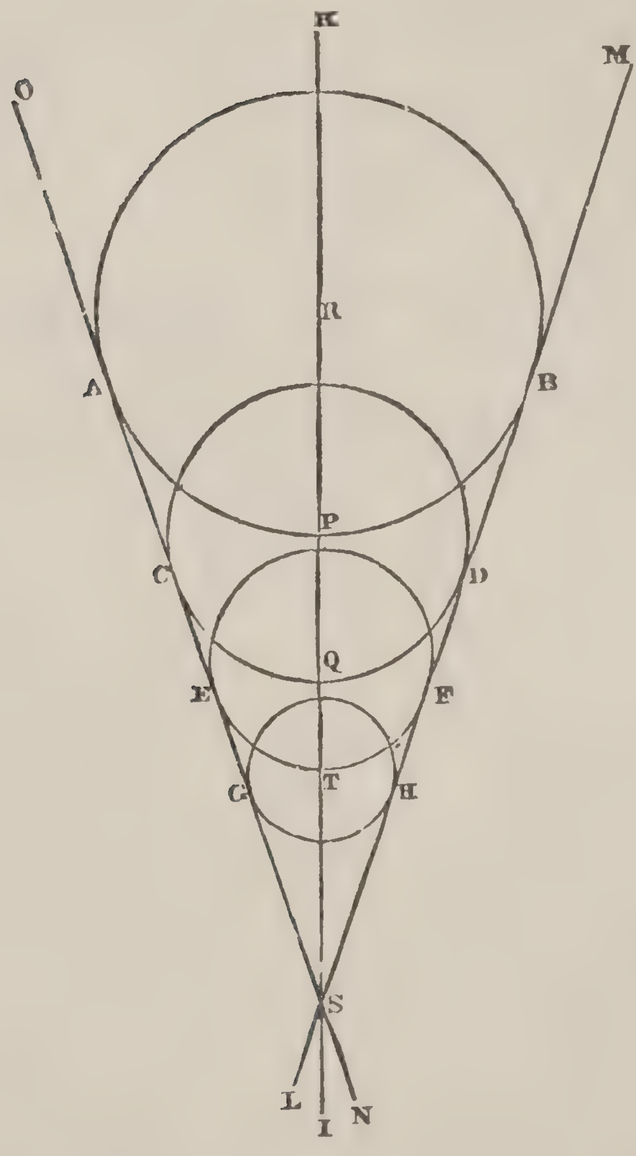
RULE.—Multiply the length of the arc D G E by its radius D C, and half the product is the area.

The length of the arc D G E equal $9\frac{1}{2}$ feet, and the radii C D, C E, equal 7 feet, required the area.

$$9{\cdot}5 \times 7 = 66{\cdot}5 \div 2 = 33{\cdot}25 \text{ the area.}$$

Proportion of Circles.

Fig. 2.



To enable machinists to enlarge or reduce machinery wheels without changing their respective motion.

First, describe two circles A B and C D the size of the largest wheels which you wish to change to a large or small machine, with the centre P of the smaller circle C D on the circumference of the large one A B; then draw two lines L M and N O tangent to the circles A B and C D, and a line I K passing through their centres P and R; then if you wish to reduce the machine, describe a circle the size you wish to reduce it to; if one-half, for example, have the centre Q one-half the distance from R to S and describe the circle E F, and on its circumference T as a centre, describe a circle G H, allowing their circumferences to touch the tangent lines

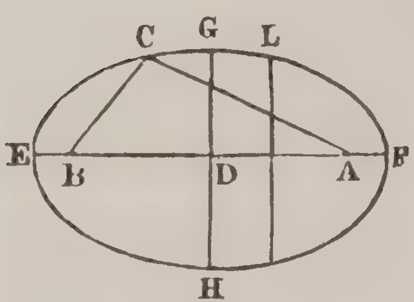
L M and N O, which will make the circle E F one-half the size of the circle A B, and G H one-half the size of C D; therefore E F and G H are in the same proportion to each other as A B and C D.

If you wish to reduce one-third, have the centre Q one-third the distance from R to S; if one-fourth, have the centre Q one-fourth the distance from R to S, and so on. This calculation may be applied beyond the centre R for enlarging machine wheels, which will enable you to make the alteration without changing their respective motion.

To describe an Ellipse, or Oval.

[Simple Method.]

Fig. 3.

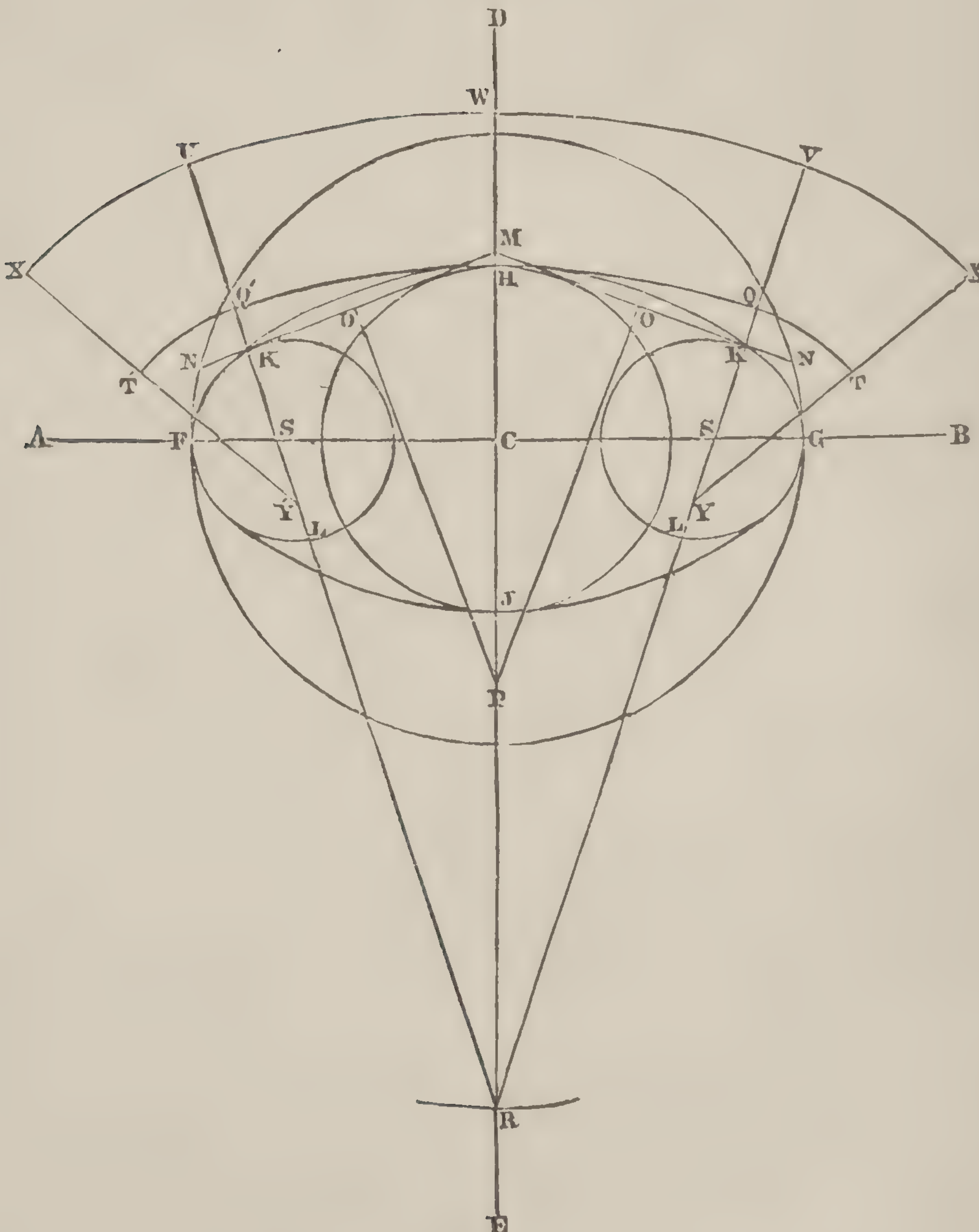


At a given distance, equal to the required eccentricity of the ellipse, place two pins, A and B, and pass a string, A C B, round them; keep the string stretched by a pencil or tracer, C, and move the pencil along, keeping the string all the while equally tense, then will the ellipse C G L F H be described. A and B are the foci of the ellipse, D the centre, D A or D B the eccentricity, E F the principal axis or longer diameter, G H the shorter diameter, and if from any point L in the curve a line be drawn perpendicular to the axis, then will L K be an ordinate to the axis corresponding to the point L, and the parts of the axis E K, K F into which L K divides it are said to be the abscissæ corresponding to that ordinate.

NOTE.—OVAL. A curve line, the two diameters of which are of unequal length, and is allied in form to the ellipse. An ellipse is that figure which is produced by cutting a cone or cylinder in a direction oblique to its axis, and passing through its sides. An oval may be formed by joining different segments of circles, so that their meeting shall not be perceived, but form a continuous curve line. All ellipses are ovals, but all ovals are not ellipses; for the term oval may be applied to all egg-shaped figures, those which are broader at one end than the other, as well as those whose ends are equally curved.

To describe an Ellipse.

Fig. 4.



To describe an ellipse of any length and width, and by it to describe a pattern for the sides of a vessel of any flare.

First draw an indefinite line D E perpendicular to the line A B, and from C, the point of intersection, as a centre, describe a circle F G, having the diameter equal to the length of the ellipse ; from the same centre C describe a circle H J equal to the width ; then

describe the end circles L K′ and L K, as much less than the width as the width is less than the length; then draw the lines M N and M N tangent to the circles K′L, H J and K L; from the middle of the line M N at O erect a perpendicular produced until it intersects the indefinite line D E; from the point of intersection P as a centre, describe the arc K′H K, and with the same sweep of the dividers mark the point R on the line D E; from the point R draw the lines R U and R V through the points K′ and K where the arc K′ H K touches the end circles K′L and K L; then place one foot of the dividers on the point R and span them to the point H, and describe the arc Q′H Q, which will be equal in length to the arc K′ H K; from the same centre R describe the arc U W V the width of the pattern; then span the dividers the diameter of the end circle K L; place one foot of the dividers on the line R V, at point Q, and the other at Y as a centre, describe the arc Q T the length of the curve line K G, and with the same sweep of the dividers describe the arc T′Q′ from the centre Y′ on the line R U; then span the dividers from Y′ to U, and from Y′ as a centre, describe the arc U X, and from Y as a centre, describe the arc V X, which completes the description of the pattern.

The more flare you wish the pattern to have, the nearer the centre point R must be to H; and the less flare, the further the centre point R must be from H; in the same proportion as you move the centre R towards, or from H, you must move the centre Y towards, or from Q, or which would be the same as spanning the dividers less, or greater, than the diameter of the end circle K L.

To find the Circumference of an Ellipse.

Rule.—Multiply half the sum of the two diameters by 3·1416, and the product will be the circumference.

Example.—Suppose the longer diameter 6 inches and the shorter diameter 4 inches, then 6 added to 4 equal 10, divided by 2 equal 5, multiplied by 3·1416 equal 15·7080 inches circumference.

To find the Area of an Ellipse.

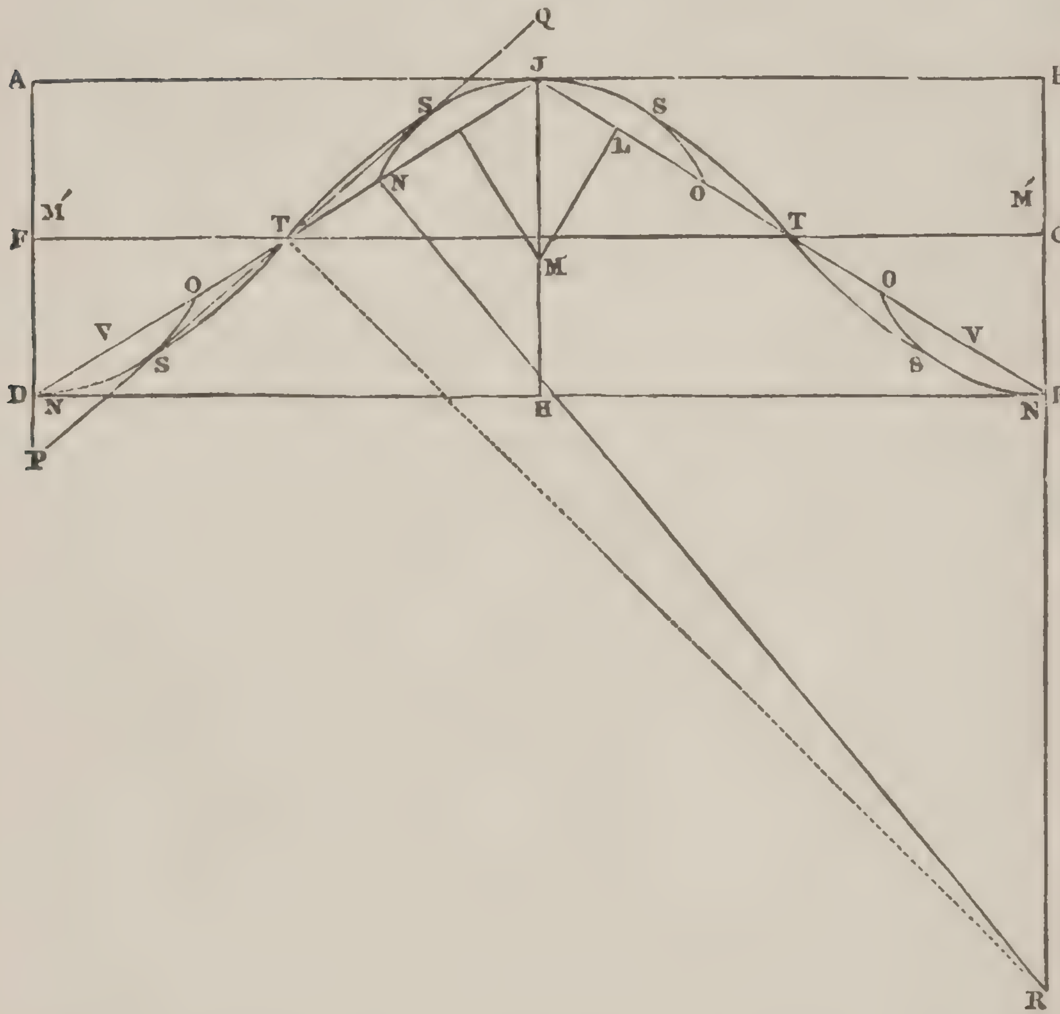
Rule.—Multiply the longer diameter by the shorter diameter, and by ·7854, and the product will be the area.

Example.—Required the area of an ellipse whose longer diameter is 6 inches and shorter diameter 4 inches.

$$6 \times 4 \times \cdot 7854 = 18\cdot 8496, \text{ the area.}$$

To describe a Right Angled Elbow.

Fig. 5.

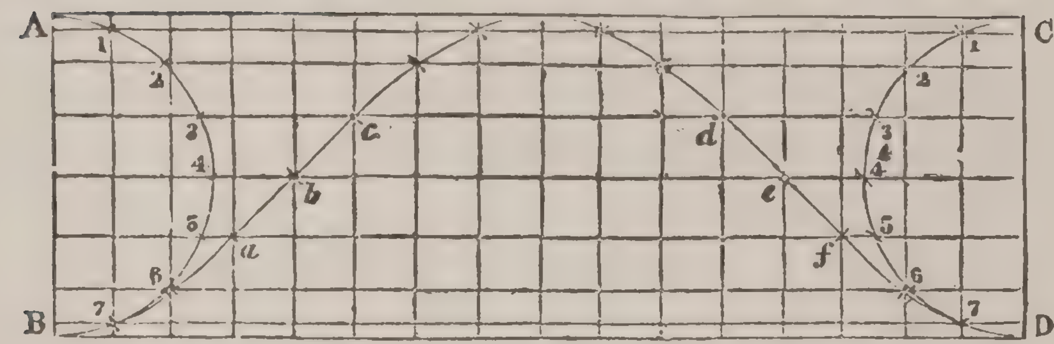


First construct a rectangle A D E B equal in width to the diameter of the elbow, and the length equal to the circumference; then from the point J, the middle of the line A B, draw the line J H, and from the point F, the middle of the line A D, draw the line F G; from the point J draw two diagonal lines J D and J E; then span the dividers so as to divide one of these diagonal lines into six equal parts, viz., J, L, O, T, O, V, E; from the point L erect a perpendicular, produced to the line J H; from the point of contact M, as a centre, describe the arc N J O for the top of the elbow, and from the points M′ and M′ as centres, with the same sweep of the dividers, describe the arcs N O and N O; then draw an indefinite straight line P Q tangent to the arcs N O and N J, having the points of contact at S and S; on this tangent line erect a perpendicular passing through the point N produced until it intersects the line B E produced; then place one foot of the dividers on the point of intersection R and span them over the dotted line to the point T, and with the dividers thus spanned describe the arcs T S, T S, T S, and T S; these arcs and the arcs N O, N J O, and O N will be the right angled elbow required.

To describe a Straight Elbow.

[Old Method.]

Fig. 6.



Mark out the length and depth of the elbow, A B C D; draw a semicircle at each end, as from A B and C D; divide each semicircle into eight parts; draw horizontal lines as shown from 1 to 1, 2 to 2, etc.; divide the circumference or length, A C B D, into sixteen equal parts, and draw perpendicular lines as in figure; draw a line from *a* to *b* and from *b* to *c*, and on the opposite side from *d* to *e* and *e* to *f;* for the top sweep set the dividers on *fourth* line from top and sweep *two* of the spaces; the same at the corner; on space for the remaining sweeps set the dividers so to intersect in the three corners of the spaces marked ×. The seams must be added to drawing.

To describe a Curved Elbow.

Fig. 7.

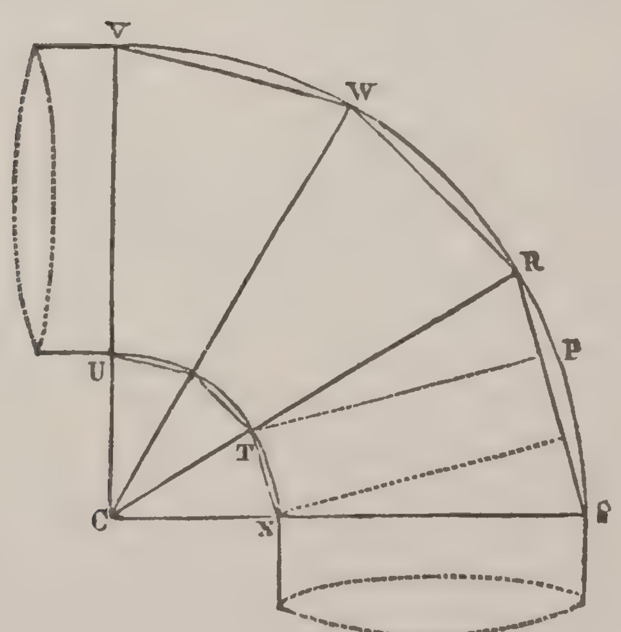
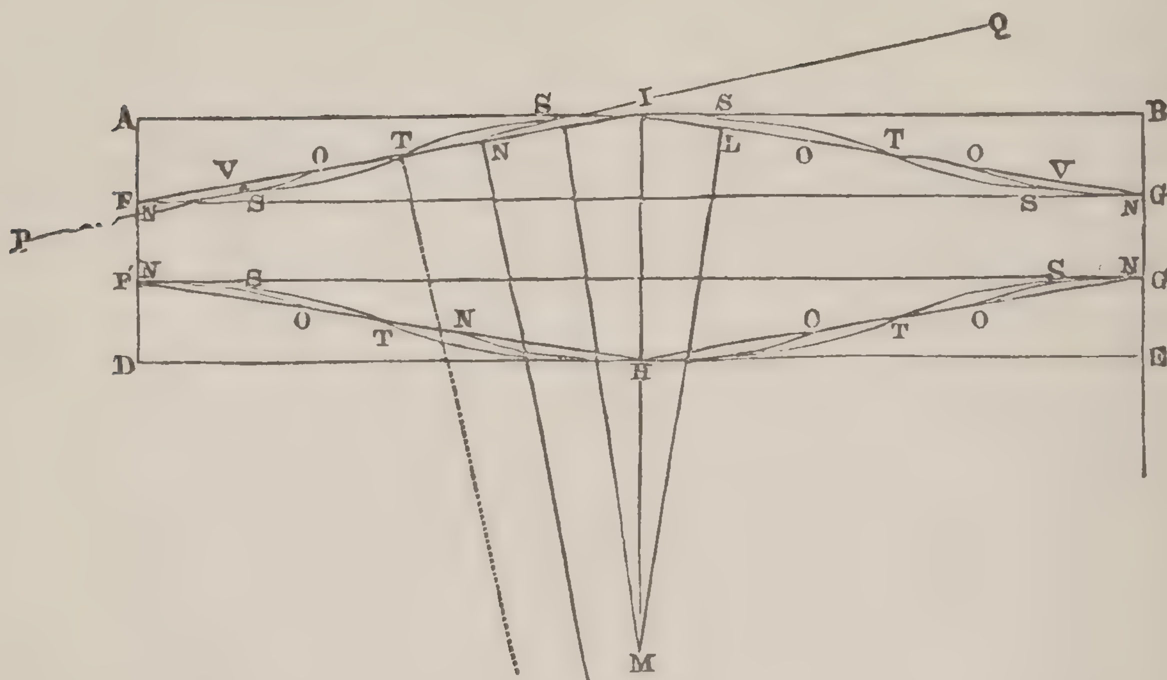


Fig. 8.



Describe two circles U X and V′S, the curves desired for the elbow, having the distance from U to V′ equal to the diameter; then divide the circle V′, W, R and S, into as many sections as desired; then construct a rectangle, *Fig.* 8, A D E B, the width equal to the width of one section V′W, *Fig.* 7, and the length equal to the circumference of the elbow: then span the dividers from the point R to the point P at the dotted line, *Fig.* 7, and with the dividers thus spanned mark the points F F′ *Fig.* 8, from points A and D, and draw the lines F G and F′G′; from point I draw the two diagonal lines I F and I G, span the dividers so as to divide one of these diagonal lines into six equal parts, viz., I, L, O, T, O, V, G; from the point L erect a perpendicular line produced until it intersects the line I H produced; from the point of intersection M, as a centre, describe the arc N I O for the top of the elbow; with the same sweep of the dividers describe the arcs N O and N O; then draw an indefinite straight line P Q tangent to the arcs N O and N I, having the points of contact at S and S; on this tangent line erect a perpendicular line passing through the point N (same as in *Fig.* 5), produced until it intersects the line B E produced; then place one foot of the dividers on the point of intersection and span them over the dotted line to the point T, (same as in *Fig.* 5), and with the dividers spanned describe the arcs T S, T S, T S, and T

S; these arcs and the arcs N O, N I O and O N, will be one side of the section, and by the same rule the other side of the section may be described at the same time, which will be a pattern to cut the other sections by.

To describe a Straight Elbow.

[Another Method for describing a Straight Elbow.]

Figs. 9 and 10.

Fig. 10. Fig. 9.

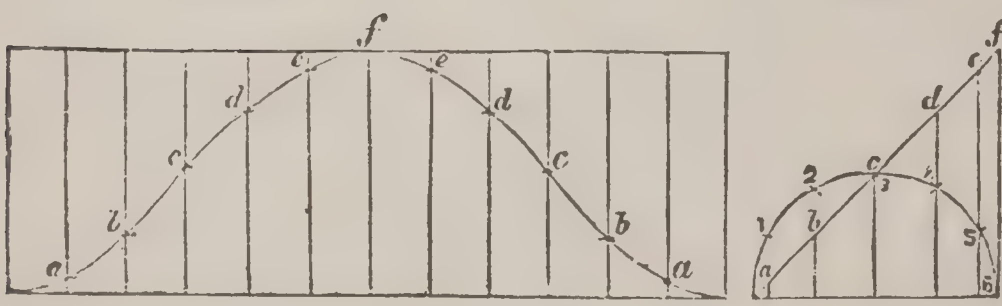
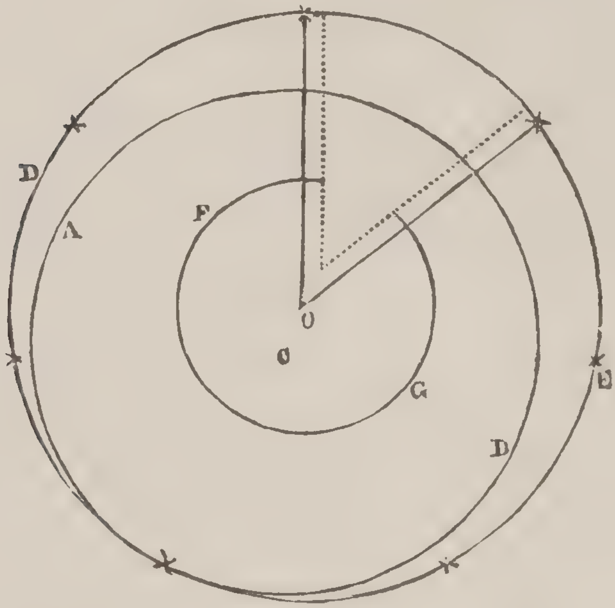


FIG. 9.—Draw a profile of half of the elbow wanted, and mark a semicircle on the line representing the diameter, divide the semicircle into six equal parts, draw perpendicular lines from each division on the circle to the angle line as on figure.

FIG. 10.—Draw the circumference and depth of elbow wanted, and divide into twelve equal parts; mark the height of perpendicular lines of *Fig.* 9 on *Fig.* 10 *a b c*, etc.; set your dividers the same as for the semicircle and sweep from *e* to *e* intersecting with *f* and the same from *a* to the *corner*, then set the dividers one-third the circumference and sweep from *e* to *d each side*, and from *a* to *b each side* at bottom; then set your dividers three-fourths of the circumference and sweep from *c* to *d each side* on top, and from *c* to *b* at bottom, and you obtain a more correct pattern than is generally used. Allow for the lap or seam outside of your drawing, and lay out the elbow deep enough to put together by swedge or machine. Be careful in dividing and marking out, and the large end will be true without trimming. The seams must be added to drawing.

To describe Bevel Covers for Vessels, or Breasts for Cans.

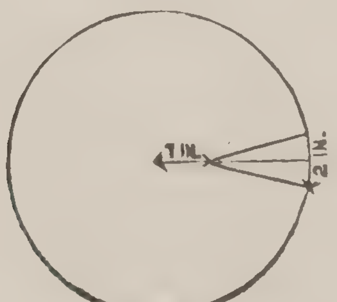
Fig. 11.



From O as a centre, describe a circle D E larger than the vessel; and from C as a centre, describe a circle A B the size of the vessel, then with the dividers the same as you described the circle the size of the vessel, apply them six times on the circumference of the circle larger than the vessel; for can-breasts describe the circle F G the size you wish for the opening of the breast.

To describe Pitched Covers for Pails, etc.

Fig. 12.

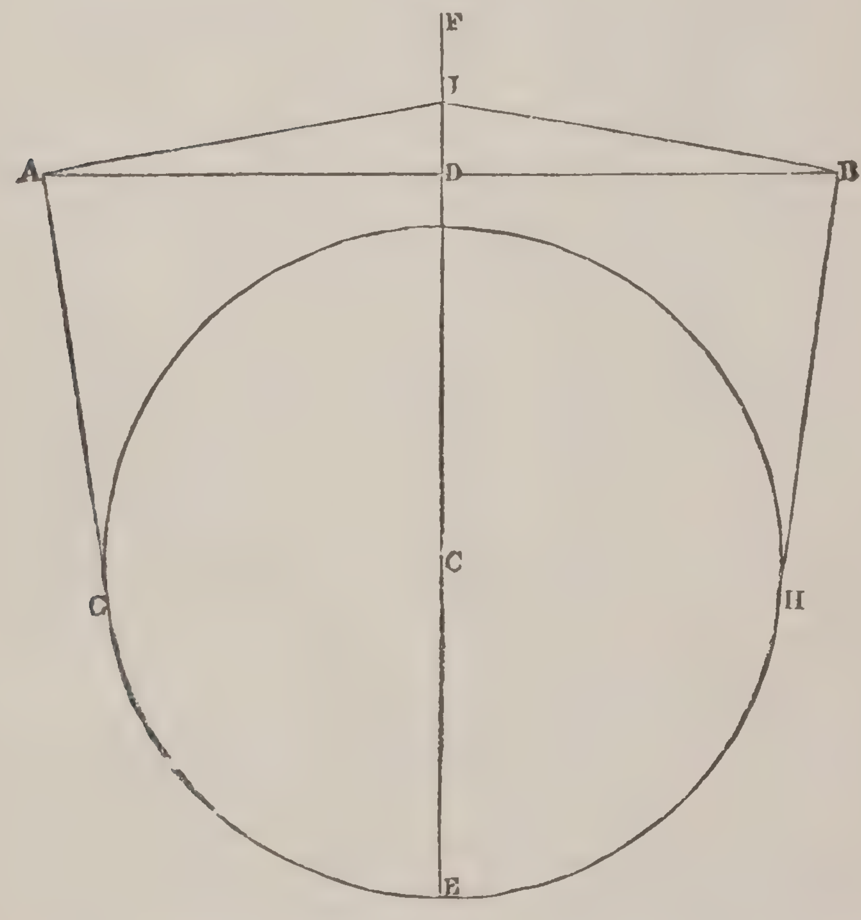


To cut for pitched covers, draw a circle one inch larger than the hoop is in diameter after burring, then draw a line from the

centre to the circumference as in the figure, and one inch from the centre and connecting with this line draw two more lines, the ends of which shall be one inch on either side of the line first drawn, and then cut out the piece.

To describe an Oval Boiler Cover.

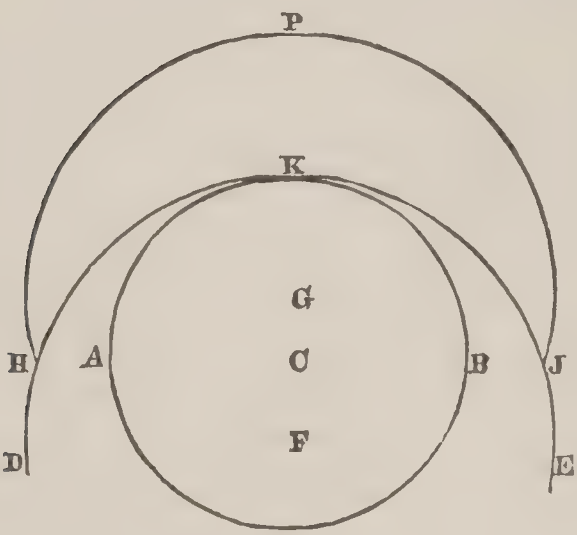
Fig. 13.



From C as a centre, describe a circle whose diameter will be equal to the width of the boiler outside of the wire, and draw the line A B perpendicular to the line E F, having it pass through the point D, which is one-half of the length of the boiler; then mark the point J one quarter of an inch or more as you wish, for the pitch of the cover, and apply the corner of the square on the line A B, allowing the blade to fall on the circle at H, and the tongue at the point J; then draw the lines H B, B J, G A and A J, which completes the description.

To describe a Lip to a Measure.

Fig. 14.



Let the circle A B represent the size of the measure; span the dividers from K to F three-quarters of the diameter; describe the semicircle D K E; move the dividers to G the width of the lip required, and describe the semicircle K P J, which will be the lip sought.

The Circle and its Sections.

1. The *Areas of Circles* are to each other as the squares of their diameters; any circle twice the diameter of another contains four times the area of the other.

2. The *Radius* of a circle is a straight line drawn from the centre to the circumference.

3. The *Diameter* of a circle is a straight line drawn through the centre, and terminated both ways at the circumference.

4. A *Chord* is a straight line joining any two points of the circumference.

5. An *Arc* is any part of the circumference.

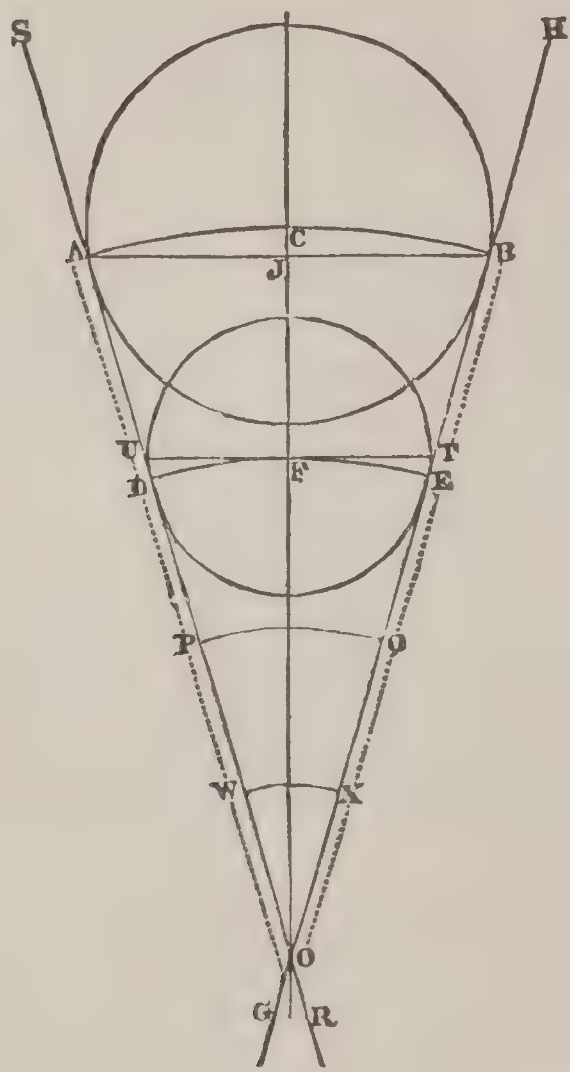
6. A *Semicircle* is half the circumference cut off by a diameter.

7. A *Segment* is any portion of a circle cut off by a chord.

8. A *Sector* is a part of a circle cut off by two radii.

To describe a Flaring Vessel Pattern, a Set of Patterns for a Pyramid Cake, or an Envelope for a Cone.

Fig. 15.



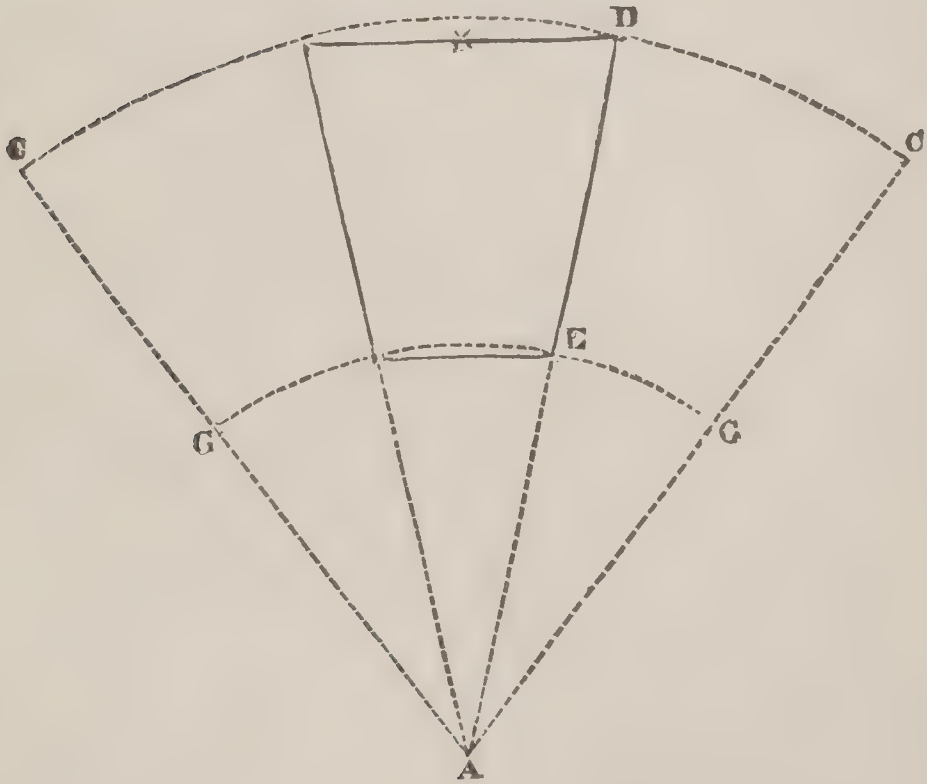
From a point C as a centre, describe a circle A B equal to the large circumference; with the point F as a centre, the depth of the vessel, describe a circle D E equal to the small circumference; then draw the lines G H and R S tangent to the circles A B and D E; from the point of intersection O as a centre, describe the arcs A C B and D F E; then A D E B will be the size of the vessel, and three such pieces will be an envelope for it, and A J B T F U the altitude: then by dividing the sector S O H into sections A B, D E, P Q, and W X, you will have a set of patterns for a pyramid

cake; and the sector A O B will be one-third of an envelope for a cone.

In allowing for locks, you must draw the lines parallel to the radii, as represented in the diagram by dotted lines, which will bring the vessel true across the top and bottom.

To describe a Cone or Frustum.

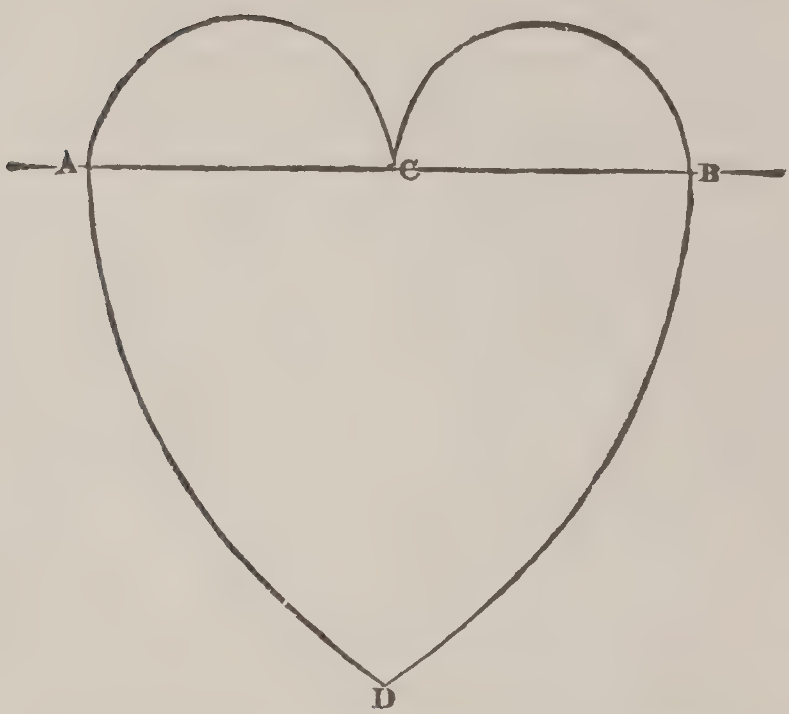
Fig. 16.



First draw a side elevation of the desired vessel, D E, then from A as a centre describe the arcs C D C and G E G; after finding the diameter of the top or large end, turn to the table of Diameters and Circumferences, where you will find the true circumference, which you will proceed to lay out on the upper or larger arc C D C, making due allowance for the locks, wire, and burr. This is for one piece; if for two pieces, you will lay out only one-half the circumference on the plate; if for three pieces, one-third; if for four pieces, one-fourth; and so on for any number, remembering to make the allowance for locks, wire, and burr on the piece you use for a pattern.

To describe a Heart.

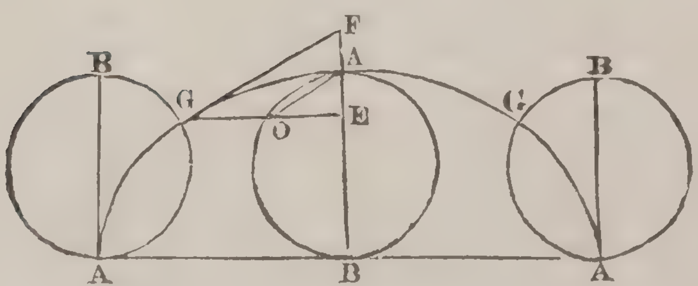
Fig. 17.



Draw an indefinite line A B; then span the dividers one-fourth the width you wish the heart, and describe two semicircumferences A C and C B; span the dividers from A to B, the width of the heart, and describe the lines A D and B D, which completes the description.

Cycloid.

Fig. 18.



Cycloid, a curve much used in mechanics. It is thus formed: If the circumference of a circle be rolled on a right line, beginning at any point A, and continued till the same point A arrives at the line again, making just one revolution, and thereby measuring

out a straight line A B A equal to the circumference of a circle, while the point A in the circumference traces out a curve line A C A G A: then this curve is called a cycloid; and some of its properties are contained in the following lemma.

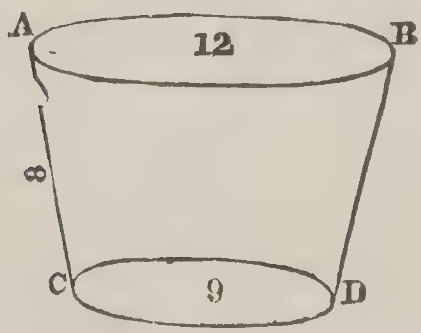
If the generating or revolving circle be placed in the middle of the cycloid, its diameter coinciding with the axis A B, and from any point there be drawn the tangent C F, the ordinate C D E perpendicular to the axis, and the chord of the circle A D; then the chief properties are these:

The right line C D equal to the circular arc A D;
The cycloidal arc A C equal to double the chord A D;
The semi-cycloid A C A equal to double the diameter A B, and
The tangent C F is parallel to the chord A D.

This curve is the line of swiftest descent, and that best suited for the path of the ball of a pendulum.

To Strike the Side of a Flaring Vessel.

Fig. 19.



To find the radius of a circle for striking the side of a flaring vessel having the diameters and depth of side given.

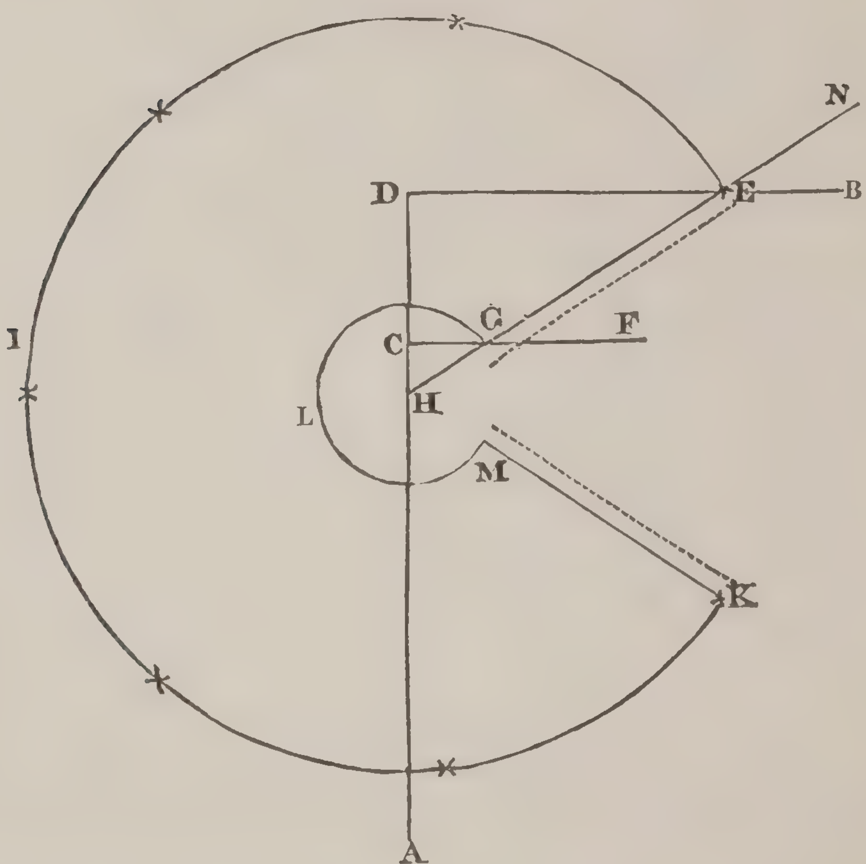
RULE. — As the difference between the large and small diameter is to the depth of the side, so is the small diameter to the radius of the circle by which it is struck.

Example. — Suppose A B C D to be the desired vessel, with a top diameter of 12 inches, bottom diameter 9 inches, depth of side 8 inches. Then as $12 - 9 = 3 : 8 :: 9$ to the radius.

$8 \times 9 = 72 \div 3 = 24$ *inches, answer.*

To describe Bevel Covers for Vessels, or Breasts for Cans.

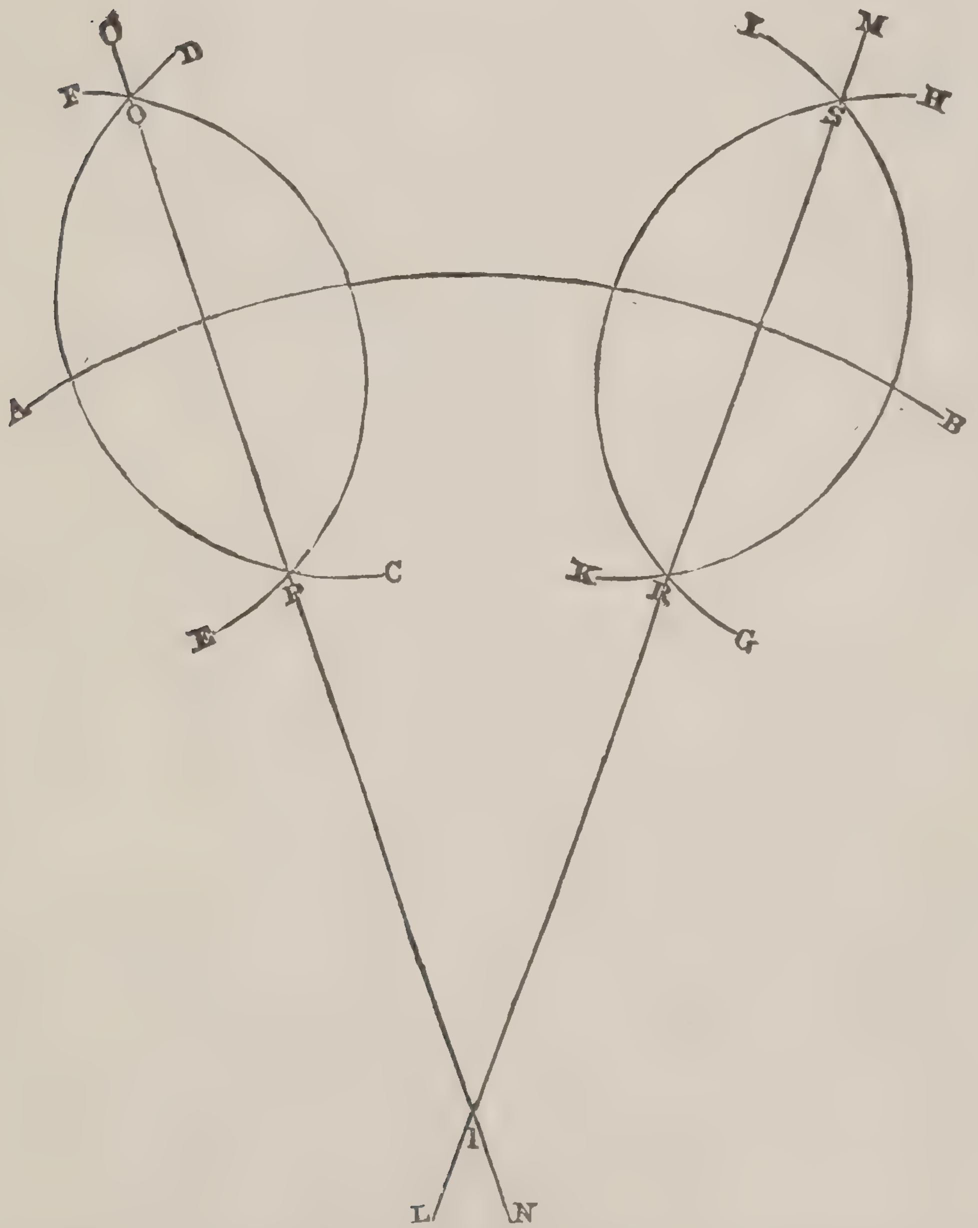
Fig. 20.



Construct a right angle A D B, and from the point C, the altitude height you wish the breast, erect a perpendicular line F; then on the line B, mark the point E one-half the diameter of the can; and on the line F, mark the point G one-half the diameter of the opening in the top of breast; draw a line N to pass through the points E and G produced until it intersects the line A; place one foot of the dividers at the point of intersection H, and place the other on the point E, and describe the circle E I K; span the dividers from the point H to point G, and describe the circle G L M; then span the dividers from the point D to E, and step them six times on the circle E I K, which gives the size of the breast. Remember to mark the lines for the locks parallel with the radii.

To Find the Centre of a Circle from a Part of the Circumference.

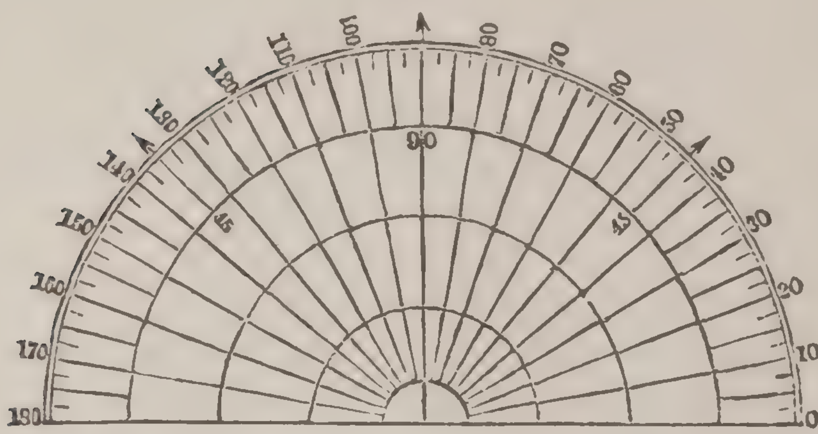
Fig. 21.



Span the dividers any distance you wish, and place one foot on the circumference A B, and describe the semicircumferences C D, E F, G H, and I K, and through the points of their intersection P Q and R S, draw two indefinite lines L M and N O; the point of their intersection T, will be the centre desired.

Sector, for Obtaining Angles.

Fig. 22.



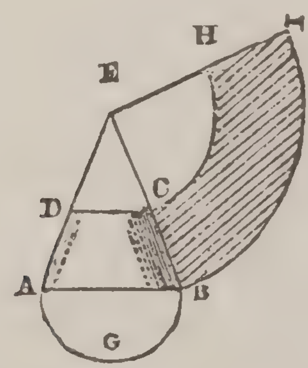
SECTOR, a portion of a circle comprehended between any two radii and their intercepted arcs. — *Similar Sectors* are those whose radii include equal angles.

To find the area of a sector. Say as 360° is to the degree, etc., in the arc of the sector, so is the area of the whole circle to the area of the sector. Or multiply the radius by the length of the arc, and half the product will be the area.

To Construct the Frustum of a Cone.

Form of flat Plate by which to construct any Frustum of a Cone.

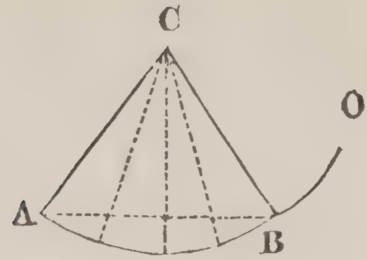
Fig. 23.



Let A B C D represent the required frustum; continue the lines A D and B C until they meet at E; then from E as centre, with the radius E C, describe the arc C H; also from E, with the radius E B, describe the arc B I; make B I equal in length to twice A G B; draw the line E I, and B C I H is the form of the plate as required.

Rule for Striking out a Cone or Frustum.

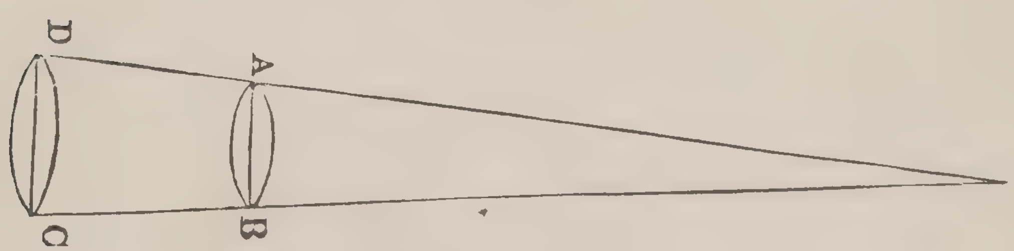
Fig. 24.



In a conical surface, there may be economy, sometimes, in having the slant height 6 times the radius of base. For a Circle may be wholly cut into conical surfaces, if the angle is 60°, 30°, 15°, etc.

But there is a greater simplicity in cutting it, when the angle is 60°. For instance, take A C equal to the slant height, describe an indefinite arc A O; with the same opening of the dividers measure from A to B; draw B C and we have the required sector. This would make the angle C equal 60°. This angle may be divided into two or four equal parts, and we should thus have sectors whose angle would be 30° or 15°, which would not make the vessel very flaring. The accompanying figure gives about the shape of the flaring vessel when the angle of the sector is 30°.

Fig. 25.



To find the Contents of a Pyramid or Cone.

Rule.—Multiply the area of the base by the height, and one-third of the product will be the solid content.

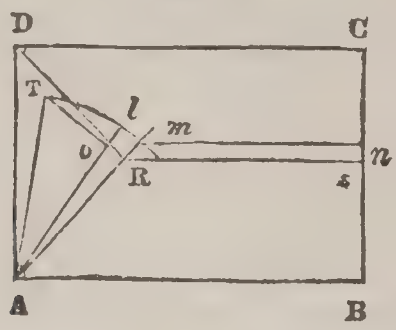
Example.—Required the solid content in inches of a Cone or Pyramid, the diameter of the base being 8 inches, and perpendicular height 18 inches?

$8 \times 8 = 64 \times \cdot 7854 \times 18 = 904 \cdot 7808 \div 3 = 301 \cdot 5936$ inches $\div 231 = 1$ gall. $1\frac{1}{4}$ qts.

Hipped Roofs, Mill Hoppers, etc.

To find the various Angles and proper Dimensions of Materials whereby to construct any figure whose form is the Frustum of a proper or inverted Pyramid, as Hipped Roofs, Mill Hoppers, etc.

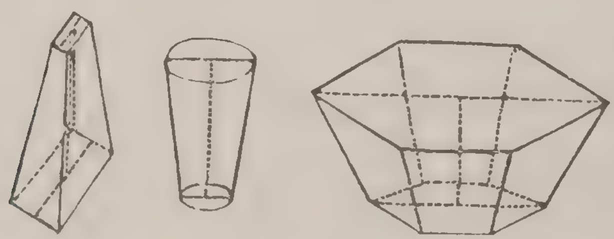
Fig. 26.



Let A B C D be the given dimensions of plan for a roof, the height R T also being given; draw the diagonal A R, meeting the top or ridge R *s* on plan; from R, at right angles with A R and equal to the required height, draw the line R T, then T A, equal the length of the struts or corners of the roof; from A, with the distance A T, describe an arc T *l*, continue the diagonal A R until it cuts the arc T *l*, through which, and parallel with the ridge R *s*, draw the line *m n*, which determines the required breadth for each side of the roof: from A, meeting the line *m n*, draw the line A *o*, or proper angle for the end of each board by which the roof might require to be covered; and the angle at T is what the boards require to be made in the direction of their thickness, when the corners or angles require to be mitred.

Contents in Gallons of the Frustum of a Cone.

Figs. 27, 28, 29.



To find the Contents in Gallons of a Vessel, whose diameter is larger at one end than the other, such as a Bowl, Pail, Firkin, Tub, Coffee-pot, etc.

RULE.— Multiply the larger diameter by the smaller, and to the product add one-third of the square of their difference, multiply by the height, and multiply that product by ·0034 for Wine Gallons, and by ·002785 for Beer.

Example. — Required the contents of a Coffee-pot 6 inches diameter at the top, 9 inches at the bottom, and 18 inches high.

Large diameter	9	Brought up	1026
Small do.	6		·0034
	54		4104
$\frac{1}{3}$ of the square	3		3078
	57		3·4884 wine gallons,
Height	18		or nearly $3\frac{1}{2}$ gallons.
	456		
	57		
Carried up	1026		

1026 multiplied by ·002785 equal 2·8574 *Beer Gallons.*

Rule to find the Contents in Gallons of any Square Vessel.

RULE.— Take the dimensions in inches and decimal parts of an inch, multiply the length, breadth, and height together, and then multiply the product by ·004329 for Wine Gallons, and by ·003546 for Ale Gallons.

Example.— How many Wine Gallons will a box contain that is 10 feet long, 5 feet wide, and 4 feet deep ?

Length in inches,	120	Brought up	345600
Breadth in do.	60		·004329
	7200		3110400
Height in inches,	48		691200
	57600		1036800
	28800		1382400
			1496·102400 gallons,
Carried up,	345600		
			or 1496 galls. and $3\frac{1}{4}$ gills.

Contents in Gallons of Cylindrical Vessels.

Rule.—Take the dimensions, in inches and decimal parts of an inch. Square the diameter, multiply it by the length in inches, and then multiply the product by ·0034 for Wine Gallons, or by ·002785 for Ale Gallons.

Example.—How many U. S. Gallons will a Cylindrical Vessel contain, whose diameter is 9 inches, and length $9\frac{1}{2}$ inches?

Diameter,	9	Brought up	769·5
	9		·0034
Square Diam.	81		30780
Length,	9·5		23085
	405		2·61630
	729		or 2 gallons and 5 pints.
Carried up,	769·5		

To Ascertain the Weights of Pipes of various Metals, and any Diameter required.

Thickness in parts of an inch.	Wrought iron.	Copper.		Lead.	
$\frac{1}{32}$	·326	$11\frac{1}{2}$ lbs. plate	·38	2 lbs. lead	·483
$\frac{1}{16}$	·653	$23\frac{1}{2}$ "	·76	4 "	·967
$\frac{3}{32}$	·976	35 "	1·14	$5\frac{1}{2}$ "	1·45
$\frac{1}{8}$	1·3	$46\frac{1}{2}$ "	1·52	8 "	1·933
$\frac{5}{32}$	1·627	58 "	1.9	$9\frac{1}{4}$ "	2·417
$\frac{3}{16}$	1·95	70 "	2·28	11 "	2·9
$\frac{7}{32}$	2·277	$80\frac{1}{2}$ "	2·66	13 "	3·383
$\frac{1}{4}$	2·6	93 "	3·04	15 "	3.867

Rule.—To the interior diameter of the pipe, in inches, add the thickness of the metal; multiply the sum by the decimal numbers opposite the required thickness and under the metal's name; also by the length of the pipe in feet, and the product is the weight of the pipe in lbs.

1. Required the weight of a copper pipe whose interior diameter is $7\frac{1}{2}$ inches, its length $6\frac{1}{4}$ feet, and the metal $\frac{1}{8}$ of an inch in thickness.

$$7·5 \times ·125 = 7·625 \times 1·52 \times 6·25 = 72·4 \text{ lbs.}$$

2. What is the weight of a leaden pipe $18\frac{1}{2}$ feet in length, 3 inches interior diameter, and the metal $\frac{1}{4}$ of an inch in thickness?

$$3 + ·25 = 3·25 \times 3·867 \times 18·5 = 232·5 \text{ lbs.}$$

Tin Plates.

Size, Length, Breadth, and Weight.

Brand Mark.	No. of Sheets in Box.	Length and Breadth.	Weight per Box.			
		Inches.	Cwt.	qr.	lbs.	
1 C	225	14 by 10	1	0	0	
1 x	225	14 by 10	1	1	0	
1 xx	225	14 by 10	1	1	21	
1 xxx	225	14 by 10	1	2	14	
1 xxxx	225	14 by 10	1	3	7	
1 xxxxx	225	14 by 10	2	0	0	
1 xxxxxx	225	14 by 10	2	0	21	
D C	100	17 by $12\frac{1}{2}$	0	3	14	In addition, a great variety of sizes are imported for special purposes, usually costing a little more in proportion than those which are esteemed regular sizes.
D x	100	17 by $12\frac{1}{2}$	1	0	14	
D xx	100	17 by $12\frac{1}{2}$	1	1	7	
D xxx	100	17 by $12\frac{1}{2}$	1	2	0	
D xxxx	100	17 by $12\frac{1}{2}$	1	2	21	
D xxxxx	100	17 by $12\frac{1}{2}$	1	3	14	
D xxxxxx	100	17 by $12\frac{1}{2}$	2	0	7	
S D C	200	15 by 11	1	1	27	
S D x	200	15 by 11	1	2	20	
S D xx	200	15 by 11	1	3	13	
S D xxx	200	15 by 11	2	0	6	
S D xxxx	200	15 by 11	2	0	27	
S D xxxxx	200	15 by 11	2	1	20	
S D xxxxxx	200	15 by 11	2	2	13	
TTT Taggers,	225	14 by 10	about 1	0	0	
1 C	225	12 by 12				About the same weight per Box, as the plates above of similar brand, 14 by 10.
1 x	225	12 by 12				
1 xx	225	12 by 12				
1 xxx	225	12 by 12				
1 xxxx	225	12 by 12				
1 C	112	14 by 20				
1 x	112	14 by 20				
1 xx	112	14 by 20				
1 xxx	112	14 by 20				
1 xxxx	112	14 by 20				
Leaded or Ternes 1 C	112	14 by 20	1	0	0	*For Roofing.*
Leaded or Ternes 1 x	112	14 by 20	1	1	0	

Oil Canisters, (*from* 2½ *to* 125 *galls.*,) **with the Quantity and Quality of Tin Required for Custom Work.**

Galls.	Quantity and Quality.	Galls.	Quantity and Quality.
2½	2 Plates, I X in body.	33	13½ Plates, IX in body, 3 breadths high.
3½	2 " S DX "		
5½	2 " DX "	45	13½ Plates, S D X in body.
8	4 " IX "	60	13½ " D X "
10	3½ " DX "	90	15¼ " D X " *
15	4 " DX "	125	20 " D X "

* The bottom tier of plates to be placed lengthwise.

Weight of Water.

1	cubic inch	is equal to	·03617	pounds.
12	cubic inches	is equal to	·434	pounds.
1	cubic foot..............	is equal to	62·5	pounds.
1	cubic foot..............	is equal to	7·50	U. S. gallons.
1·8	cubic feet..............	is equal to	112·00	pounds.
35·84	cubic feet..............	is equal to	2240·00	pounds.
1	Cylindrical inch	is equal to	·02842	pounds.
12	Cylindrical inches...	is equal to	·341	pounds.
1	Cylindrical foot......	is equal to	49·10	pounds.
1	Cylindrical foot......	is equal to	6·00	U. S. gallons.
2·282	Cylindrical feet......	is equal to	112·00	pounds.
45·64	Cylindrical feet......	is equal to	2240·00	pounds.
11·2	Imperial gallons.....	is equal to	112·00	pounds.
224	Imperial gallons.....	is equal to	2240·00	pounds.
13·44	United States galls.	is equal to	112·00	pounds.
268·8	United States galls.	is equal to	2240·00	pounds.

Centre of pressure is at two-thirds depth from surface.

Decimal Equivalents to the Fractional Parts of a Gallon, or an Inch.

[*The Inch, or Gallon, being divided into 32 parts.*]

[In multiplying decimals it is usual to drop all but the first two or three figures.]

Decimals.	Gallon, or Inch.	Gills.	Pints.	Quarts.	Decimals.	Gallon, or Inch.	Gills.	Pints.	Quarts.	Decimals.	Gallon, or Inch.	Gills.	Pints.	Quarts.
·03125	1-32	1	¼	⅛	·375	3-8	12	3	1½	·71875	23-32	23	5¾	2⅞
·0625	1-16	2	½	¼	·40625	13-32	13	3¼	1⅝	·75	3-4	24	6	3
·09375	3-32	3	¾	⅜	·4375	7-16	14	3½	1¾	·78125	25-32	25	6¼	3⅛
·125	1-8	4	1	½	·46875	15-32	15	3¾	1⅞	·8125	13-16	26	6½	3¼
·15625	5-32	5	1¼	⅝	·5	1-2	16	4	2	·84375	27-32	27	6¾	3⅜
·1875	3-16	6	1½	¾	·53125	17-32	17	4¼	2⅛	·875	7-8	28	7	3½
·21875	7-32	7	1¾	⅞	·5625	9-16	18	4½	2¼	·90625	29-32	29	7¼	3⅝
·25	1-4	8	2	1	·59375	19-32	19	4¾	2⅜	·9375	15-16	30	7½	3¾
·28125	9-32	9	2¼	1⅛	·625	5-8	20	5	2½	·96875	31-32	31	7¾	3⅞
·3125	5-16	10	2½	1¼	·65625	21-32	21	5¼	2⅝	1·000	1	32	8	4
·34375	11-32	11	2¾	1⅜	·6875	11-16	22	5½	2¾					

Application. — Required the *gallons* in any Cylindrical Vessel. Suppose a vessel $9\frac{1}{2}$ inches deep, 9 inches diameter, and contents 2·6163, that is, 2 gallons and 61 hundredth parts of a gallon; now to ascertain this decimal of a gallon, refer to the above Table for the decimal that is nearest, which is ·625, opposite to which is $\frac{5}{8}$ths of a gallon, or 20 gills, or 5 pints, or $2\frac{1}{2}$ quarts, consequently the vessel contains 2 gallons and 5 pints.

Inches. — To find what part of an inch the decimal ·708 is. Refer to the above Table for the decimal that is nearest, which is ·71875, opposite to which is 23-32, or nearly $\frac{3}{4}$ths of an inch.

A TABLE CONTAINING THE DIAMETERS, CIRCUMFERENCES, AND AREAS OF CIRCLES, AND THE CONTENT OF EACH IN GALLONS AT ONE FOOT IN DEPTH.

UTILITY OF THE TABLE.

EXAMPLES.

1. Required the circumference of a circle, the diameter being *five* inches?

In the column of circumferences, opposite the given diameter, stands 15·708 * inches, the circumference required.

2. Required the capacity, in gallons, of a can, the diameter being 6 feet and depth 10 feet?

In the fourth column from the given diameter stands 211·4472,* being the content of a can 6 feet in diameter and 1 foot in depth, which being multiplied by 10 gives the required content, two thousand one hundred fourteen and a half gallons.

3. Any of the areas in feet multiplied by ·03704, the product equal the number of cubic yards at 1 foot in depth.

4. The area of a circle in inches multiplied by the length or thickness in inches, and by ·263, the product equal the weight in pounds of cast iron.

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* See preceding page for Decimal Equivalents to the Fractional parts of a Gallon and an Inch.

Diameters and Circumferences of Circles, and the Content in Gallons at 1 Foot in Depth.

[*Area in Inches.*]

Diam.	Circ. in.	Area in.	Gallons.	Diam.	Circ. in.	Area in.	Gallons.
1 in.	3·1416	·7854	·04084	$6\frac{1}{2}$	20·420	33·183	1·72552
$\frac{1}{8}$	3·5343	·9940	·05169	$\frac{5}{8}$	20·813	34·471	1·79249
$\frac{1}{4}$	3·9270	1·2271	·06380	$\frac{3}{4}$	21·205	35·784	1·86077
$\frac{3}{8}$	4·3197	1·4848	·07717	$\frac{7}{8}$	21·598	37·122	1·93034
$\frac{1}{2}$	4·7124	1·7671	·09188	7 in.	21·991	38·484	2·00117
$\frac{5}{8}$	5·1051	2·0739	·10784	$\frac{1}{8}$	22·383	39·871	2·07329
$\frac{3}{4}$	5·4978	2·4052	·12506	$\frac{1}{4}$	22·776	41·282	2·14666
$\frac{7}{8}$	5·8905	2·7611	·14357	$\frac{3}{8}$	23.169	42·718	2·22134
2 in.	6·2832	3·1416	·16333	$\frac{1}{2}$	23·562	44·178	2·29726
$\frac{1}{8}$	6·6759	3·5465	·18439	$\frac{5}{8}$	23·954	45·663	2·37448
$\frac{1}{4}$	7·0686	3·9760	·20675	$\frac{3}{4}$	24·347	47·173	2·45299
$\frac{3}{8}$	7·4613	4·4302	·23036	$\frac{7}{8}$	24·740	48·707	2·53276
$\frac{1}{2}$	7·8540	4·9087	·25522	8 in.	25·132	50·265	2·61378
$\frac{5}{8}$	8·2467	5·4119	·28142	$\frac{1}{8}$	25·515	51·848	2·69609
$\frac{3}{4}$	8·6394	5·9395	·30883	$\frac{1}{4}$	25·918	53·456	2·77971
$\frac{7}{8}$	9·0321	6·4918	·33753	$\frac{3}{8}$	26·310	55·088	2·86458
3 in.	9·4248	7·0686	·36754	$\frac{1}{2}$	26·703	56·745	2·95074
$\frac{1}{8}$	9·8175	7·6699	·39879	$\frac{5}{8}$	27·096	58·426	3·03815
$\frac{1}{4}$	10·210	8·2957	·43134	$\frac{3}{4}$	27·489	60·132	3·12686
$\frac{3}{8}$	10·602	8·9462	·46519	$\frac{7}{8}$	27·881	61·862	3·21682
$\frac{1}{2}$	10·995	9·6211	·50029	9 in.	28·274	63·617	3·30808
$\frac{5}{8}$	11·388	10·320	·53664	$\frac{1}{8}$	28·667	65·396	3·40059
$\frac{3}{4}$	11·781	11·044	·57429	$\frac{1}{4}$	29·059	67·200	3·49440
$\frac{7}{8}$	12·173	11·793	·61324	$\frac{3}{8}$	29·452	69·029	3·58951
4 in.	12·566	12·566	·65343	$\frac{1}{2}$	29·845	70·882	3·68586
$\frac{1}{8}$	12·959	13·364	·69493	$\frac{5}{8}$	30·237	72·759	3·78347
$\frac{1}{4}$	13·351	14·186	·73767	$\frac{3}{4}$	30·630	74·662	3·88242
$\frac{3}{8}$	13·744	15·033	·78172	$\frac{7}{8}$	31·023	76·588	3·98258
$\frac{1}{2}$	14·137	15·904	·82701	10 in.	31·416	78·540	4·08408
$\frac{5}{8}$	14·529	16·800	·87360	$\frac{1}{8}$	31·808	80·515	4·18678
$\frac{3}{4}$	14·922	17·720	·92144	$\frac{1}{4}$	32·201	82·516	4·29083
$\frac{7}{8}$	15·315	18·665	·97058	$\frac{3}{8}$	32·594	84·540	4·39608
5 in.	15·708	19·635	1·02102	$\frac{1}{2}$	32·986	86·590	4·50268
$\frac{1}{8}$	16·100	20·629	1.07271	$\frac{5}{8}$	33·379	88·664	4·61053
$\frac{1}{4}$	16·493	21·647	1·12564	$\frac{3}{4}$	33·772	90·762	4·71962
$\frac{3}{8}$	16·886	22·690	1·17988	$\frac{7}{8}$	34·164	92·885	4·82846
$\frac{1}{2}$	17·278	23·758	1·23542	11 in.	34·557	95·033	4·94172
$\frac{5}{8}$	17·671	24·850	1·29220	$\frac{1}{8}$	34·950	97·205	5·05466
$\frac{3}{4}$	18·064	25·967	1·35028	$\frac{1}{4}$	35·343	99·402	5·16890
$\frac{7}{8}$	18·457	27·108	1·40962	$\frac{3}{8}$	35·735	101·623	5·28439
6 in.	18·849	28·274	1·47025	$\frac{1}{2}$	36·128	103·869	5·40119
$\frac{1}{8}$	19·242	29·464	1·53213	$\frac{5}{8}$	36.521	106·139	5·51923
$\frac{1}{4}$	19·635	30·679	1·59531	$\frac{3}{4}$	36·913	108·434	5·63857
$\frac{3}{8}$	20·027	31·919	1·65979	$\frac{7}{8}$	37·306	110·753	5·75916

Diameters and Circumferences of Circles, and the Content in Gallons at 1 Foot in Depth.—(*Continued.*)

[*Area in Feet.*]

Diam. Ft.	Diam. In.	Circ. Ft.	Circ. In.	Area in ft.	Gallons. 1 ft. depth.
1		3	1⅝	·7854	5·8735
1	1	3	4⅝	·9217	6·8928
1	2	3	8	1·0690	7·9944
1	3	3	11	1·2271	9·1766
1	4	4	2⅛	1·3962	10·4413
1	5	4	5⅜	1·5761	11·7866
1	6	4	8½	1·7671	13·2150
1	7	4	11⅝	1·9689	14·7241
1	8	5	2¾	2·1816	16·3148
1	9	5	5⅞	2·4052	17·9870
1	10	5	9	2·6398	19·7414
1	11	6	2¼	2·8852	21·4830
2		6	3⅜	3·1416	23·4940
2	1	6	6½	3·4087	25·4916
2	2	6	9⅝	3·6869	27·5720
2	3	7	0¾	3·9760	29·7340
2	4	7	3⅞	4·2760	32·6976
2	5	7	7	4·5869	34·3027
2	6	7	10¼	4·9087	36·7092
2	7	8	1⅝	5·2413	39·1964
2	8	8	4½	5·5850	41·7668
2	9	8	7⅝	5·9395	44·4179
2	10	8	10¾	6·3049	47·1505
2	11	9	1⅞	6·6813	49·9654
3		9	5	7·0686	52·8618
3	1	9	8¼	7·4666	55·8382
3	2	9	11⅜	7·8757	58·8976
3	3	10	2½	8·2957	62·0386
3	4	10	5⅝	8·7265	65·2602
3	5	10	8¾	9·1683	68·5193
3	6	10	11⅞	9·6211	73·1504
3	7	11	3	10·0846	75·4166
3	8	11	6⅛	10·5591	78·9652
3	9	11	9⅜	11·0446	82·5959
3	10	12	5½	11·5409	86·3074
3	11	12	3⅝	12·0481	90·1004
4		12	6¾	12·5664	93·9754
4	1	12	9⅞	13·0952	97·9310
4	2	13	1	13·6353	101·9701
4	3	13	4⅛	14·1862	103·0300
4	4	13	7¼	14·7479	110·2907
4	5	13	10½	15·3206	114·5735
4	6	14	1⅝	15·9043	118·9386
4	7	14	4⅝	16·4986	123·3830
4	8	14	7⅞	17·1041	127·9112
4	9	14	11	17·7205	132·5209
4	10	15	2⅛	18·3476	137·2105
4	11	15	5¼	18·9858	142·0582
5		15	8½	19·6350	146·8384
5	1	15	11⅝	20·2947	151·7718
5	2	16	2¾	20·9656	156·7891
5	3	16	5¾	21·6475	161·8886
5	4	16	9	22·3400	167·0674
5	5	17	0⅛	23·0437	172·3300
5	6	17	3¼	23·7583	177·6740
5	7	17	6⅜	24·4835	183·0973
5	8	17	9⅝	25·2199	188·6045
5	9	18	0¾	25·9672	194·1930
5	10	18	3⅞	26·7251	199·8610
5	11	18	7⅛	27·4943	205·6133
6		18	10⅛	28.2744	211·4472
6	3	19	7½	30·6796	229·4342
6	6	20	4⅞	33·1831	248·1564
6	9	21	2⅜	35·7847	267·6122
7		21	11⅞	38·4846	287·8032
7	3	22	9¼	41·2825	308·7270
7	6	23	6¾	44·1787	330·3859
7	9	24	4⅛	47·1730	352·7665
8		25	1½	50·2656	375·9062
8	3	25	11	53·4562	399·7668
8	6	26	8⅜	56·7451	424·3625
8	9	27	5¾	60·1321	449·2118
9		28	3¼	63·6174	475·7563
9	3	29	0⅝	67·2007	502·5536
9	6	29	10⅛	70·8823	530·0861
9	9	30	7½	74·6620	558·3522
10		31	5	78·5400	587·3534
10	3	32	2⅜	82·5160	617·0876
10	6	32	11¾	86·5903	647·5568
10	9	33	9¼	90·7627	678·2797

Diam.		Circ.		Area in ft·	Gallons.	Diam.		Circ.		Area in ft.	Gallons.
Ft.	In.	Ft.	In.		1 ft. depth.	Ft.	In.	Ft.	In.		1 ft. depth.
11		34	6⅝	95·0334	710·6977	21		65	11⅝	346·3614	2590·2290
11	3	35	4⅛	99·4021	743·3686	21	3	66	9	354·6571	2652·2532
11	6	36	1½	103·8691	776·7746	21	6	67	6½	363·0511	2715·0413
11	9	36	10⅞	108·4342	810·9143	21	9	68	3⅞	371·5432	2778·5486
12		37	8⅜	113·0976	848·1890	22		69	1⅜	380·1336	2842·7910
12	3	38	5¾	117·8590	881·3966	22	3	69	10¾	388·8220	2907·7664
12	6	39	3¼	122·7187	917·7395	22	6	70	8¼	397·6087	2973·4889
12	9	40	0⅝	127·6765	954·8159	22	9	71	5⅝	406·4935	3039·9209
13		40	10	132·7326	992·6274	23		72	3	415·4766	3107·1001
13	3	41	7½	137·8867	1031·1719	23	3	73	0½	424·5577	3175·0122
13	6	42	4⅞	143·1391	1070·4514	23	6	73	9⅞	433·7371	3243·6595
13	9	43	2¼	148·4896	1108·0645	23	9	74	7¼	443.0146	3313·0403
14		43	11¾	153·9384	1151·2129	24		75	4¾	452·3904	3383.1563
14	3	44	9⅛	159·4852	1192·6940	24	3	76	2⅛	461·8642	3454·0051
14	6	45	6⅝	165·1303	1234·9104	24	6	76	11⅝	471·4363	3525·5929
14	9	46	4	170·8735	1277·8615	24	9	77	9	481·1065	3597.9068
15		47	1½	176·7150	1321·5454	25		78	6⅜	490·8750	3670·9596
15	3	47	10⅞	182·6545	1365·9634	25	3	79	3⅞	500·7415	3744·7452
15	6	48	8¼	188·6923	1407·5165	25	6	80	1¼	510·7063	3819·2657
15	9	49	5¾	194·8282	1457.0032	25	9	80	10¾	520·7692	3894·5203
16		50	3⅛	201·0624	1503·6250	26		81	8⅛	530·9304	3970·5098
16	3	51	0½	207·3946	1550·9797	26	3	82	5¼	541·1896	4047·2322
16	6	51	10	213·8251	1599·0696	26	6	83	3	551·5471	4124·6898
16	9	52	7⅜	220·3537	1647·8930	26	9	84	0⅜	562·0027	4202·9610
17		53	4⅞	226·9806	1697·4516	27		84	9⅞	572·5566	4281·8072
17	3	54	2⅛	233·7055	1747·7431	27	3	85	8⅛	583·2085	4361·4664
17	6	54	11⅝	240·5287	1798·7698	27	6	86	4⅝	593·9587	4441·8607
17	9	55	9⅛	247·4500	1850·5301	27	9	87	2⅛	604·8070	4522·9886
18		56	6½	254·4696	1903·0254	28		87	11½	615·7536	4604·8517
18	3	57	4	261·5872	1956·2537	28	3	88	9	626·7982	4686·4876
18	6	58	1⅜	268·8031	2010·2171	28	6	89	6⅜	637·9411	4770·7787
18	9	58	10¾	276·1171	2064·9140	28	9	90	3¾	649·1821	4854·8434
19		59	8¼	283·5294	2120·3462	29		91	1¼	660·5214	4939·6432
19	3	60	5⅝	291·0397	2176·5113	29	3	91	10⅝	671·9587	5025·1759
19	6	61	3⅛	298·6483	2233·2914	29	6	92	8⅛	683·4943	5111·4487
19	9	62	0½	306·3550	2291·0452	29	9	93	5½	695·1280	5198·4451
20		62	9⅞	314·1600	2349·4141	30		94	2⅞	706·8600	5286·1818
20	3	63	⅜	322·0630	2408·5159	30	3	95	0⅜	718·6900	5374·6512
20	6	64	4¾	330·0643	2468·3528	30	6	95	9¾	730·6183	5463·8558
20	9	65	2¼	338·1637	2528·9233	30	9	96	7¼	742·6447	5553·7940

Capacity of Cans One Inch Deep.

UTILITY OF THE TABLE.

Required the contents of a vessel, diameter 6 7-10*ths* inches, depth 10 inches?

By the table a vessel 1 inch deep and 6 and 7-10*ths* inches diameter contains ·15 (hundredths) of a gallon, then ·15 × 10 = 1·50 or 1 gallon and 2 quarts.

Required the contents of a can, diameter 19 8-10*ths* inches, depth 30 inches?

By the table a vessel 1 inch deep and 19 and 8-10*ths* inches diameter contains 1 gallon and ·33 (hundredths), then 1·33 × 30 = 39·90 or nearly 40 gallons.

Required the depth of a can whose diameter is 12 and 2-10*ths* inches, to contain 16 gallons.

By the table a vessel 1 inch deep and 12 and 2-10*ths* inches diameter contains ·50 (hundredths) of a gallon, then 16 ÷ ·50 = 32 inches, the depth required, viz.:

·50) 16 (32 × ·50 = 16 gallons.

Diameter.		$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$
3	·03	·03	·03	·03	·03	·04	·04	·04	·04	·05
4	·05	·05	·05	·05	·06	·06	·07	·07	·07	·08
5	·08	·08	·08	·09	·09	·10	·10	·11	·11	·11
6	·12	·12	·12	·13	·13	·14	·14	·15	·15	·16
7	·16	·17	·17	·18	·18	·19	·19	·20	·20	·21
8	·21	·22	·22	·23	·23	·24	·25	·25	·26	·26
9	·27	·28	·28	·29	·30	·30	·31	·31	·32	·33
10	·34	·34	·35	·36	·36	·37	·38	·38	·39	·40
11	·41	·41	·42	·43	·44	·44	·45	·46	·47	·48
12	·48	·49	·50	·51	·52	·53	·53	·54	·55	·56
13	·57	·58	·59	·60	·60	·61	·62	·63	·64	·65
14	·66	·67	·68	·69	·70	·71	·72	·73	·74	·75
15	·76	·77	·78	·79	·80	·81	·82	·83	·84	·85
16	·87	·88	·89	·90	·91	·92	·93	·94	·95	·97
17	·98	·99	1·005	1·017	1·028	1·040	1·051	1·063	1·075	1·086
18	1·101	1·113	1·125	1.138	1·150	1·162	1·170	1·187	1·200	1·211
19	1·227	1·240	1·253	1·266	1·279	1·292	1·304	1·317	1·330	1·343
20	1·360	1·373	1·385	1·400	1·414	1·428	1·441	1·455	1·478	1·482
21	1·499	1·513	1·527	1·542	1·556	1·570	1·585	1·600	1·612	1·630
22	1·645	1·660	1·675	1·696	1·705	1·720	1·735	1·750	1·770	1·780
23	1·798	1·814	1·830	1·845	1·861	1·876	1·892	1·908	1·923	1·940
24	1·958	1·974	1·991	2·007	2·023	2·040	2·056	2·072	2·096	2·105
25	2·125	2·142	2·159	2·176	2·193	2·210	2·227	2·244	2·261	2·280
26	2·298	2·316	2·333	2·351	2·369	2·386	2·404	2·422	2·440	2·460
27	2·478	2·496	2·515	2·533	2·552	2·570	2·588	2·607	2·625	2·643
28	2·665	2·684	2·703	2·722	2·741	2·764	2·780	2·800	2·820	2·836
29	2·859	2·879	2·898	2·918	2·938	2·958	2·977	2·997	3·017	3·036
30	3·060	3·080	3·100	3·121	3·141	3·162	3·182	3·202	3·223	3·245
31	3·267	3·288	3·309	3·330	3·351	3·372	3·393	3·414	3·436	3·457
32	3·481	3·503	3·524	3·543	3·568	3·590	3·612	3·633	3·655	3·689
33	3·702	3·725	3·747	3·773	3·795	3·814	3·837	3·860	3·882	3·904
34	3·930	3·953	3·976	4·003	4·022	4·046	4·070	4·092	4·115	4·140
35	4·165	4·188	4·212	4·236	4·260	4·284	4·307	4·331	4·355	4·380
36	4·406	4·430	4·455	4·483	4·503	4·528	4·553	4·577	4·602	4·626
37	4·654	4·679	4·704	4·730	4·755	4·780	4·805	4·834	4·855	4·880
38	4·909	4·935	4·961	4·987	5·012	5·038	5·064	5·090	5·120	5·142
39	5·171	5·197	5·224	5·250	5·277	5·304	5·330	5·357	5·383	5·410
40	5·440	5·467	5·491	5·521	5·548	5·576	5·603	5·630	5·657	5·684

Definition of Arithmetical Signs used in the Work.

$=$ When we wish to state that one quantity or number is equal to another quantity or number, the sign of *equality* $=$ is employed. Thus 3 added to $2 = 5$, or 3 added to 2 is equal to 5.

$+$ When the sum of two quantities or numbers is to be taken, the sign *plus* $+$ is placed between them. Thus $3 + 2 = 5$, that is, the sum of 3 and 2 is 5. This is the sign of Addition.

$-$ When the difference of two numbers or quantities is to be taken, the sign *minus* $-$ is used, and shows that the latter number or quantity is to be taken from the former. Thus $5 - 2 = 3$. This is the sign of Subtraction.

$\times$ When the product of any two numbers or quantities is to be taken, the sign *into* $\times$ is placed between them. Thus $3 \times 2 = 6$. This is the sign of Multiplication.

$\div$ When we are to take the quotient of two quantities, the sign *by* $\div$ is placed between them, and shows that the former is to be divided by the latter. Thus $6 \div 2 = 3$. This is the sign of Division. But in some cases in this work, the mode of division has been to place the dividend above a horizontal line, and the divisor below it, in the form of a vulgar fraction, thus:

$$\frac{\text{Dividend}}{\text{Divisor}} = \text{Quotient.} \qquad \frac{6}{2} = 3.$$

When the square of any number or quantity is to be taken, this is denoted by placing a small figure 2 above it to the right. Thus 6^2 shows that the square of 6 is to be taken, and therefore $6^2 = 6 \times 6 = 36$.

When we wish to show that the square root of any number or quantity is to be taken, this is denoted by placing the *radical sign* $\sqrt{}$ before it. Thus $\sqrt{36}$ shows that the square root of 36 ought to be taken, hence $\sqrt{36} = 6$.

The common marks of proportion are also used, viz., : : : : as 3 : 6 : : 4 : 8, being read 3 is to 6 as 4 is to 8.

The application of these signs to the expression of rules is exceedingly simple. Thus, connected with the circle we have the following rules:

1st. The circumference of a circle will be found by multiplying the diameter by 3·1416.

2d. The diameter of a circle may be found by dividing the circumference by 3·1416.

3d. The area of a circle may be found by multiplying the half of the diameter by the half of the circumference, or by multiplying together the diameter and circumference, and dividing the product by 4, or by squaring the diameter, and multiplying by ·7854.

Now all these rules may be thus expressed:

1st. $\text{diameter} \times 3{\cdot}1416 = \text{circumference.}$

2d. $$\frac{\text{circumference}}{3{\cdot}1416} = \text{diameter.}$$

3d. $$\frac{\text{diameter}}{2} \times \frac{\text{circumference}}{2} = \text{area.}$$

or, $$\frac{\text{diameter} \times \text{circumference}}{4} = \text{area.}$$

or, $\text{diameter}^2 \times {\cdot}7854 = \text{area.}$

PRACTICAL GEOMETRY.

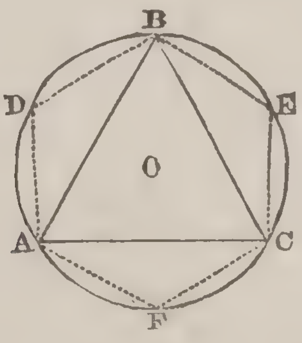
PRACTICAL Geometry is an important branch of knowledge to all who are in any way engaged in the art of building. The workman, as well as the designer, requires its aid; and unless he is acquainted with some of the leading principles of the science, he will frequently feel an uncertainty as to the results he may deduce from the problems which are presented to his notice.

PROBLEM I.

To inscribe an Equilateral Triangle within a given Circle.

Let A B C be a circle; it is required to draw within it a triangle whose sides are equal to one another. Commencing from any

Fig. 30.



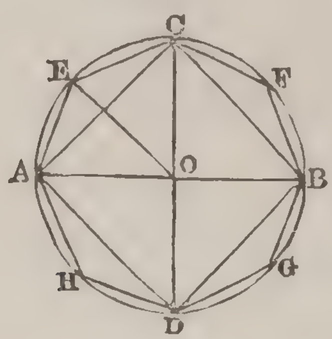
point A. mark on the circumference of the circle a series of spaces equal to the radius of the circle, of which there will be six, and draw the arcs A D D B, etc. Then join every alternate point as A B, B C, C A, and the several lines will together form an equilateral triangle.

PROBLEM II.

Within a given Circle to inscribe a Square.

Let A B C D be the given circle, it is required to draw a square within it. Draw the diameters A B, C D, at right angles to each

Fig. 31.



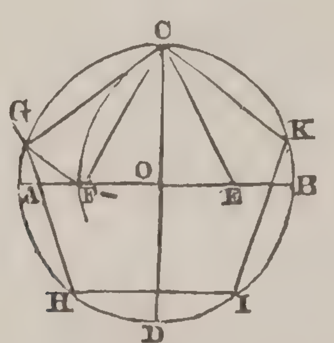
other; or, in other words, draw the diameter A B, and form a perpendicular bisecting it. Then join the points A C, C B, B D, D A, and the figure A B C D is a square formed within a given circle.

PROBLEM III.

Within a given Circle to inscribe a regular Pentagon; that is, a Polygon of five Sides.

Let A B C D be a circle in which it is required to draw a pentagon. Draw a diameter A D, and perpendicular to it another diameter.

Fig. 32.



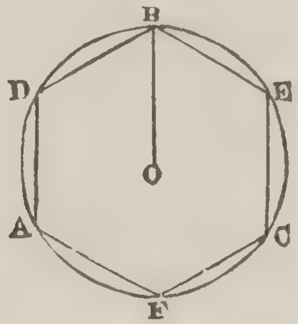
Then divide O B into two equal parts in the point E, and join C E; and with E as a centre, and the radius C E, draw the arc C F, cutting A O in F; and, with C as a centre, and the same radius, describe the arc F G; the arcs C F, G F intersect each other in the point F, and the arc G F intersects the circumference of the circle in the point G. Join the points C and G, and that line will be a side of the pentagon to be drawn. Mark off within the circumference the same space, and join the points A H, H I, I K, K C, and the figure that is formed is a pentagon.

PROBLEM IV.

Within a given Circle to describe a regular Hexagon; that is to say, a Polygon of six equal Sides.

Let A B C be the given circle, and O the centre. With the radius of the circle divide it into parts, of which there will be six, and

Fig. 33.



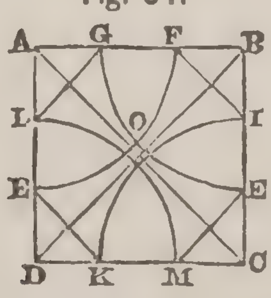
connect the points A D, D B, etc., and the figure A D B E C F will be a regular hexagon.

PROBLEM V.

To cut off the Corners of a given Square, so as to form a regular Octagon.

Let A B C D be the given square. Draw the two diagonal lines A C, and B D, crossing each other in O. Then, with the radius A O, that is, half the diagonal, and with A as a centre, describe the arc E F, cutting the sides of the square in E and F; then, from B

Fig. 34.



as a centre, describe the arc G H; and in like manner from C and D describe the arcs I K and L M. Draw the lines L G, F I, H M, and K E, and these, with the parts of the given square G F, I H, M K, and E L, form the octagon required.

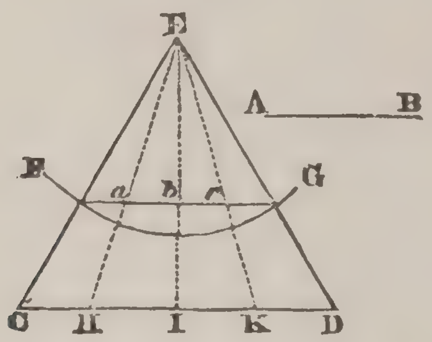
PROBLEM VI.

To divide a given Line into any Number of Parts, which Parts shall be in the same Proportion to each other as the Parts of some other given Line, whether those Parts are equal or unequal.

Let A B be the given line which it is required to divide in the same manner and proportion as the line C D, whether the parts are

equal or unequal. On the base line C D, form an equilateral triangle in the manner already described in a former problem. Then take the distance A B, and with E as a centre, describe the arc F G, and join the points F and G, and F G shall be equal to A B. Now,

Fig. 35.



if from the points H I K, which are the divisions of the line C, we draw lines to E, as H E, I E, and K E, these lines will cut F G in the points a b c, which will divide the line F G into parts proportionate to the divisions of the line C D.

Problem VII.

On a given Line to draw a Polygon of any Number of Sides, so that that Line shall be one side of a Polygon; or, in other words, to find the Centre of a Circle which shall circumscribe any Polygon, the Length of the Side of the Polygon being given.

We shall here show, in a tabular form, the length of the radius of a circle, which shall contain the given line, as a side of the required polygon; and here we will suppose the line to be divided into one thousand equal parts, and the radius into a certain number of like parts. The radius of the circle for different figures will be as follows:

For an inscribed	Triangle	577
	Square	701
	Pentagon	850
	Hexagon	1000
	Heptagon	1152
	Octagon	1306½
	Enneagon	1462
	Decagon	1618
	Endecagon	1775
	Dodecagon	1932

By this table the workman may, with a simple proportion, find the radius of a circle which shall contain a polygon, one side being given: thus, if it be required to draw a pentagon, the side given being fifteen inches, we may say as 1000 is to 15, so is 850, the tabular number for a pentagon, to 12 inches and seventy-five hun-

dredth parts of an inch, or seven-tenths and a half of a tenth of an inch.

We may here give another table for the construction of polygons, one in which the radius of the circumscribing circle is given. If it be required to find the side of the inscribed polygon, the radius being one thousand parts, the sides of the different polygons will be according to the following scale:

The Triangle	1732
Square	1414
Pentagon	1175
Hexagon	1000
Heptagon	867½
Octagon	765
Enneagon	684
Decagon	618
Endecagon	563½
Dodecagon	517½

Here, as in the case already mentioned, the law of proportion applies, and the statement may be thus made: as one thousand is to the number of inches contained in the radius of the given circle, so is the tabular number for the required polygon to the length of one of its sides in inches. Thus, let it be supposed that we have a circle whose radius in inches is 30, and that we wish to inscribe an octagon within it; then say as 1000 is to 30 inches, so is 765 to 22 inches and 95-100 parts of an inch, the length of the side of the required octagon.

Method of Drawing Curved Lines.

We will now introduce a few remarks upon the method of drawing curved lines, and also give some rules for finding the forms of mouldings when they are to mitre together, that is to say, of raking mouldings, and of bevel work in general. It will also be necessary to make a few remarks upon the form of ribs for domes and groins, a knowledge of which is so necessary to the builder that without it the workman cannot correctly execute his task. It is hardly necessary to state, that all these mechanical operations are founded upon geometrical principles; and, unless he is acquainted with these, the workman cannot hope to succeed in his attempt to excel in his art,—one which is necessary for the comfort and convenience of all communities.

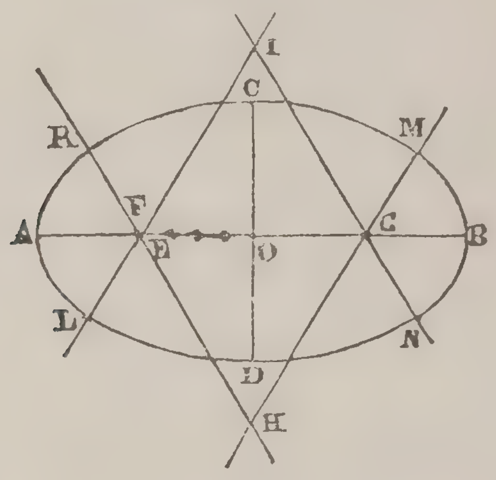
Problem VIII.

To draw an Ellipse with the Rule and Compasses, the transverse and conjugate Diameters being given; that is, the length and width.

Let A B be the transverse or longest diameter; C D the conjugate or shortest diameter; and O the point of their intersection, that

is, the centre of the ellipse. Take the distance O C or O D; and, taking A as one point, mark that distance A E upon the line A O. Divide O E into three equal parts, and take from A F, a distance E F, equal to one of those parts. Make O G equal to O F. With the radius F G, and F and G as centres, strike arcs which shall intersect each other in the points I and H. Then draw the lines H

Fig. 36.

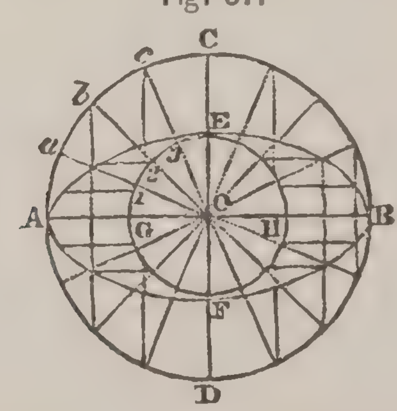


F K, H G M, and I F L, I G N. With F as a centre, and the radius A F, describe the arc L A K; and, from G as a centre, with the same radius, describe the arc M B N. With the radius H C, and H as a centre, describe the arc K C M; and, from the point I, with the radius I D, describe the arc L D M. The figure A C B D is an ellipse, formed of four arcs of circles.

Problem IX.

To draw an Ellipse by means of two Concentric Circles.

Fig. 37.



Let A B be the transverse, and E F the conjugate diameter, and O the centre of an ellipse to be drawn. From O with the radius

O A, describe the circle A C B D, and from the same centre describe another circle G E H F. Divide the outer circle into any number of equal parts; the greater the number, the more exact will be the ellipse: and they should not be less than twelve. From each of these divisions draw lines to the centre O, as *a* O, *b* O, *c* O. Then, from *a*, *b*, *c*, etc., draw lines perpendicular to A B, and from the corresponding points in the inner circle, that is, from the points marked 1, 2, 3, etc., draw lines parallel to A B. Draw a curve through the points where these lines intersect each other, and it will be an ellipse.

In the diagram to which this demonstration refers, only one quarter of the ellipse is lettered, but the process described in relation to that must be carried round the circles, as is shown in the dotted and other lines.

PROBLEM X.

To describe an Ellipse by Means of a Carpenter's Square, or a piece of notched Lath.

Having drawn two lines to represent the diameters of the ellipse required, fasten the square so that the internal angle or meeting of the blade and stock shall be at the centre of the ellipse. Then take a piece of wood or a lath, and cut it to the length of half the longest diameter, and from one end cut out a piece equal to half the shortest diameter, and there will then be a piece remaining at one end equal to the difference of the half of the two diameters. Place this projecting piece of the lath in such a manner that it may rest against the square, on the edge which corresponds to the two diameters; then, turning it round horizontally, the two ends of the projection will slide along the two internal edges of the square, and if a pencil be fixed at the other end of the lath, it will describe one quarter of an ellipse. The square must then be moved for the successive quarters of the ellipse, and the whole figure will thus be easily formed.

This method of forming an ellipse is a good substitute for the usual plan, and the figure thus produced is more accurate than that made by passing a pencil round a string moving upon two pins or nails fixed in the foci, for the string is apt to stretch, and the pencil cannot be guided with the accuracy required.

There are many other methods of drawing ellipses, or more properly ovals, but we can only notice two of those in common use.

1. By ordinates, or lines drawn perpendicular to the axis. Having formed the two diameters, divide the axis, or larger diameter, into any number of equal parts, and erect lines perpendicular to the several points. Next draw a semicircle, and divide its diameter into the like number of equal parts; that is, if the larger diameter or axis of the intended ellipse be divided into twenty equal parts, then the semicircle must be divided into the like number. As the diameter of the semicircle is equal to the shorter

diameter of the ellipse, or conjugate axis, perpendiculars may be raised from these divisions of the diameter, or the semicircle, till they meet the circumference; and the different perpendiculars, which are called ordinates, may be erected like perpendiculars, on the axis of ellipse. Joining the several points together, the ellipse is described; and the more accurately the perpendiculars are formed, the more exact will be the ellipse.

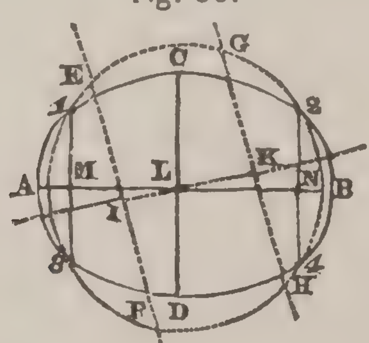
2. By intersecting arches. Take any point in the axis, and with a radius equal to the distance of that point from one extremity of the axis, and with one of the foci as a centre, describe an arc; then with the distance of the assumed point in the axis from the other end of it, and with the other focus as a centre, describe another arc intersecting the former, and the point of intersection will be a point in the ellipse. By assuming any number of points in the axis, any number of points on the curve may be found, and these united will give the ellipse. This process is founded on the property of the ellipse; that if any two lines are drawn from the foci to any point in the curve, the length of these lines added together will be a constant quantity, that is, always the same in the same ellipse.

PROBLEM XI.

To find the Centre and the two Axes of an Ellipse.

Let A B C D be an ellipse, it is required to find its centre. Draw any two lines, as E F and G H, parallel and equal to each other.

Fig. 38.



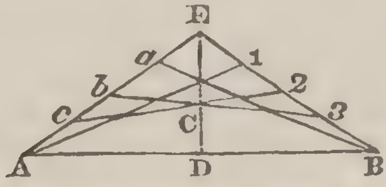
Bisect these lines as in the points I and K, and bisect I K as in L. From L, as a centre, draw a circle cutting the ellipse in four points, 1, 2, 3, 4. Now L is the centre of the ellipse. But join the points 1, 3, and 2, 4; and bisect these lines as in M and N. Draw the line M N, and produce it to A and B, and it will be the transverse axis. Draw C D through L, and perpendicular to A B, and it will be the conjugate or shorter axis.

Problem XII.

To draw a flat Arch by the intersection of Lines, having the Opening and Spring or Rise given.

Let A D B be the opening, and C D its spring or rise. In the middle of A B, at D, erect a perpendicular D E, equal to twice C D, its rise; and from E draw E A and E B, and divide A E and B E into

Fig. 39.



any number or equal parts, as a, b, c, and 1, 2, 3. Join B a, 3 c, 2 b, and 1 A, and it will form the arch required.

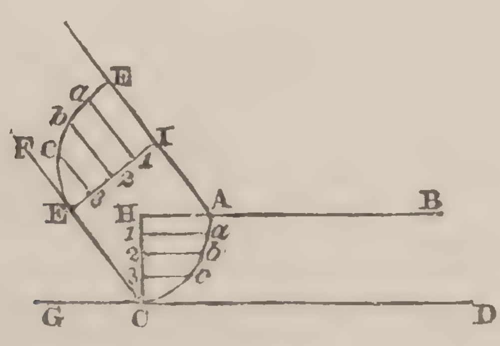
The more parts A E and B E are divided into, the greater will be the accuracy of the curve.

Many curves may be made in the same manner, according to the position of the lines A E and E B; and if instead of two lines drawn from A and B, meeting in E, a perpendicular be erected at the same points, and two lines be then drawn from the ends of these perpendiculars meeting in an angle, and these lines be divided into any number of equal parts, the points of the adjacent lines may be joined, and a curve will be formed resembling a Gothic arch. The demonstration already given is therefore very useful to the workman, as he may vary the form of the curve by altering the position of the lines, either with respect to the angles which they make with each other, or their proportional lengths.

Problem XIII.

To find the Form or Curvature of a Raking Moulding that shall unite correctly with a Level one.

Fig. 40.



Let A B C D be part of the level moulding, which we will here suppose to be an ovolo, or quarter round; A and C, the points where the raking moulding takes its rise on the angle; F C G, the angle the raking moulding makes with the horizontal one. Draw

C F at the given angle, and from A draw A E parallel to it; continue B A to H, and from C make C H perpendicular to A H. Divide C H into any number of equal parts, as 1, 2, 3, and draw lines parallel to H A, as 1 *a*, 2 *b*, 3 *c*; and then in any part of the raking moulding, as I, draw I K perpendicular to E A, and divide I K into the same number of equal parts H C is divided into; and draw 1 *a*, 2 *b*, 3 *c*, parallel to E A. Then transfer the distances 1 *a*, 2 *b*, 3 *c*, and a curve drawn through these points will be the form of the curve required for the raking moulding.

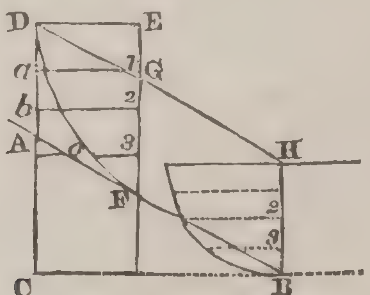
We have here shown the method to be employed for an ovolo; but it is just the same for any other formed moulding, as a cavetto, semirecta, etc. It may be worthy remark, that, after the moulding is worked, and the mitre is cut in the mitre-box for the level moulding, the raking moulding must be cut, either by the means of a wedge formed to the required angle of the rake, or a box made to correspond to that angle: and if this be accurately done, the mitre will be true, and the moulding in all its members correspond to the level moulding. The plane in which the raking moulding is situated is square to that of the level one. This is always the case in a pediment, the mouldings of which correspond with the return.

Problem XIV.

To find the Form or Curvature of the Return in an open or broken Pediment.

Let A B C be the angle which the pediment makes with the cornice, and let the form and size of the moulding be as in the last problem, and as shown at D A B H. From D drop a perpendicular

Fig. 41.



on C B, and draw D E perpendicular to D C, or parallel to C B; and let D E be equal to E I (Fig. 40). Then from E draw E F parallel to D A, and divide E F into the same number of parts as I K (Fig. 40), at 1 *a*, 2 *b*, 3 *c*, and transfer the distances 1 *a*, 2 *b*, 3 *c*, as in Fig. 40. Then a curve line drawn through the points *a*, *b*, *c*, will be the form of the return for the moulding of the open pediment.

The mitre for the return is cut in the usual manner, but that of the pediment is cut to the proper angle of its inclination, as in the last problem. In fixing the mitre, the portion E D G of the return must be cut away to make it come flush with the top of the pediment moulding.

EPITOME OF MENSURATION.

Of the Circle, Cylinder, Sphere, etc.

1. The *circle* contains a greater area than any other plane figure bounded by an equal perimeter or outline.

2. The *areas of circles* are to each other as the squares of their diameters.

3. The *diameter of a circle* being 1, its circumference equals 3·1416.

4. The *diameter of a circle* is equal to ·31831 of its circumference.

5. The square of the diameter of a *circle* being 1, its area equals ·7854.

6. The square root of the area of a *circle*, multiplied by 1·12837, equals its diameter.

7. The diameter of a *circle* multiplied by ·8862, or the circumference multiplied by ·2821, equals the side of a square of equal area.

8. The sum of the squares of half the chord and versed sine divided by the versed sine, the quotient equals the diameter of corresponding circle.

9. The chord of the whole *arc of a circle* taken from eight times the chord of half the arc, one-third of the remainder equals the length of the arc; or,

10. The number of degrees contained in the *arc of a circle*, multiplied by the diameter of the circle and by ·008727, the product equals the length of the arc in equal terms of unity.

11. The length of the arc of a *sector of a circle* multiplied by its radius, equals twice the area of the sector.

12. The area of the *segment of a circle* equals the area of the sector, minus the area of a triangle whose vertex is the centre, and whose base equals the chord of the segment; or,

13. The *area of a segment* may be obtained by dividing the height of the segment by the diameter of the circle, and multiplying the corresponding tabular area by the square of the diameter.

14. The sum of the diameters of two *concentric circles* multiplied by their difference and by ·7854, equals the area of the ring or space contained between them.

15. The sum of the thickness and internal diameter of a *cylindric ring*, multiplied by the square of its thickness and by 2·4674, equals its solidity.

16. The circumference of a *cylinder*, multiplied by its length or height, equals its convex surface.

17. The area of the end of a *cylinder*, multiplied by its length, equals its solid contents.

18. The area of the internal diameter of a *cylinder*, multiplied by its depth, equals its cubical capacity.

19. The square of the diameter of a *cylinder*, multiplied by its length and divided by any other required length, the square root of the quotient equals the diameter of the other cylinder of equal contents or capacity.

20. The square of the diameter of a *sphere*, multiplied by 3·1416, equals its convex surface.

21. The cube of the diameter of a *sphere*, multiplied by ·5236, equals its solid contents.

22. The height of any spherical *segment* or *zone*, multiplied by the diameter of the sphere of which it is a part, and by 3·1416, equals the area or convex surface of the segment; or,

23. The height of the *segment*, multiplied by the circumference of the sphere of which it is a part, equals the area.

24. The solidity of any *spherical segment* is equal to three times the square of the radius of its base, plus the square of its height, and multiplied by its height and by ·5236.

25. The solidity of a *spherical zone* equals the sum of the squares of the radii of its two ends, and one-third the square of its height, multiplied by the height and by 1·5708.

26. The capacity of a *cylinder*, 1 foot in diameter and 1 foot in length, equals 5·875 of a United States gallon.

27. The capacity of a *cylinder*, 1 inch in diameter and 1 foot in length, equals ·0408 of a United States gallon.

28. The capacity of a *cylinder*, 1 inch in diameter and 1 inch in length, equals ·0034 of a United States gallon.

29. The capacity of a *sphere*, 1 foot in diameter, equals 3·9156 United States gallons.

30. The capacity of a *sphere*, 1 inch in diameter, equals ·002165 of a United States gallon; hence,

31. The capacity of any other *cylinder* in United States gallons is obtained by multiplying the square of its diameter by its length, or the capacity of any other sphere by the cube of its diameter, and by the number of United States gallons contained as above in the unity of its measurement.

Of the Square, Rectangle, Cube, etc.

1. The side of a *square* equals the square root of its area.
2. The area of a *square* equals the square of one of its sides.
3. The diagonal of a *square* equals the square root of twice the square of its side.
4. The side of a *square* is equal to the square root of half the square of its diagonal.
5. The side of a *square* equal to the diagonal of a given square contains double the area of a given square.
6. The area of a *rectangle* equals its length multiplied by its breadth.
7. The length of a *rectangle* equals the area divided by the breadth; or, the breadth equals the area divided by the length.

8. The side or end of a *rectangle* equals the square root of the sum of the diagonal and opposite side to that required, multiplied by their difference.

9. The diagonal in a *rectangle* equals the square root of the sum of the squares of the base and perpendicular.

10. The solidity of a *cube* equals the area of one of its sides, multiplied by the length or breadth of one of its sides.

11. The length or breadth of a side of a *cube* equals the cube root of its solidity.

12. The capacity of a 12-inch *cube* equals 7·4784 United States gallons.

Surfaces and Solidities of the Regular Bodies, each of whose Boundary Lines is 1.

No. of Sides.	Names.	Surfaces.	Solids.
4	Tetrahedron.	1·7321	0·1179
6	Hexahedron.	6.	1.
8	Octahedron.	3·4641	0·4714
12	Dodecahedron.	20·6458	7·6631
20	Icosahedron.	8·6603	2·1817

The tabular surface multiplied by the square of one of the boundary lines equals the surface required; or,

The tabular solidity multiplied by the cube of one of the boundary lines equals the solidity required.

Of Triangles, Polygons, etc.

1. The complement of an *angle* is its defect from a right angle.

2. The supplement of an *angle* is its defect from two right angles.

3. The sine, tangent, and secant of an *angle* are the cosine, cotangent, and cosecant of the complement of that angle.

4. The hypothenuse of a right-angled *triangle* being made radii, its sides become the sines of the opposite angles, or the cosines of the adjacent angles.

5. The three angles of every *triangle* are equal to two right angles; hence the oblique angles of a right-angled triangle are each others complements.

6. The sum of the squares of the two given sides of a right-angled *triangle* is equal to the square of the hypothenuse.

7. The difference between the squares of the hypothenuse and given side of a right-angled *triangle* is equal to the square of the required side.

8. The area of a *triangle* equals half the product of the base multiplied by the perpendicular height; or,

9. The area of a *triangle* equals half the product of the two sides and the natural sine of the contained angle.

10. The side of any regular *polygon* multiplied by its apothegm or perpendicular, and by the number of its sides, equals twice the area.

Table of the Areas of Regular Polygons, each of whose Sides is Unity.

Name of Polygon.	No. of Sides.	Apothegm or Perpend'lar.	Area when Side is Unity.	Interior Angle.	Central Angle.
Triangle.....	3	0·2887	0·4330	60° 0′	120° 0′
Square........	4	0·5	1·	90 0	90 0
Pentagon.....	5	0·6882	1·7205	108 0	72 0
Hexagon	6	0·8660	2·5981	120 0	60 0
Heptagon....	7	1·0386	3·6339	128 34$\frac{2}{7}$	51 25$\frac{3}{7}$
Octagon......	8	1·2071	4·8284	135 0	45 0
Nonagon....	9	1·3737	6·1818	140 0	40 0
Decagon......	10	1·5388	7·6942	144 0	36 0
Undecagon..	11	1·7028	9·3656	147 16$\frac{4}{11}$	32 43$\frac{7}{11}$
Dodecagon...	12	1·8660	11·1962	150 0	30 0

The tabular area of the corresponding polygon multiplied by the square of the side of the given polygon equals the area of the given polygon.

Of Ellipses, Cones, Frustums, etc.

1. The square root of half the sum of the squares of the two diameters of an *ellipse* multiplied by 3·1416 equals its circumference.

2. The product of the two axes of an *ellipse* multiplied by ·7854 equals its area.

3. The curve surface of a *cone* is equal to half the product of the circumference of its base multiplied by its slant side, to which, if the area of the base be added, the sum is the whole surface.

4. The solidity of a *cone* equals one-third of the product of its base multiplied by its altitude or height.

5. The squares of the diameters of the two ends of the *frustum of a cone* added to the product of the two diameters, and that sum multiplied by its height and by ·2618, equals its solidity.

INSTRUMENTAL ARITHMETIC,

OR UTILITY OF THE SLIDE RULE.

The slide rule is an instrument by which the greater portion of operations in arithmetic and mensuration may be advantageously performed, provided the lines of division and gauge-points be made properly correct, and their several values familiarly understood.

The lines of division are distinguished by the letters A B C D; A B and C being each divided alike, and containing what is termed a double radius, or double series of logarithmic numbers, each series being supposed to be divided into 1000 equal parts, and distributed along the radius in the following manner:

From 1 to	2	contains	301	of those parts,	being	the log. of	2.
"	3	"	477	"	"	"	3.
"	4	"	602	"	"	"	4.
"	5	"	699	"	"	"	5.
"	6	"	778	"	"	"	6.
"	7	"	845	"	"	"	7.
"	8	"	903	"	"	"	8.
"	9	"	954	"	"	"	9.

1000 being the whole number.

The line D on the improved rules consists of only a single radius; and although of larger radius, the logarithmic series is the same, and disposed of along the line in a similar proportion, forming exactly a line of square roots to the numbers on the lines B C.

Numeration.

Numeration teaches us to estimate or properly value the numbers and divisions on the rule in an arithmetical form.

Their values are all entirely governed by the value set upon the first figure, and being decimally reckoned, advance tenfold from the commencement to the termination of each radius: thus, suppose 1 at the joint be one, the 1 in the middle of the rule is ten, and 1 at the end, one hundred; again, suppose 1 at the joint ten, 1 in the middle is 100, and 1 or 10 at the end is 1000, etc., the intermediate divisions on which complete the whole system of its notation.

To Multiply Numbers by the Rule.

Set 1 on B opposite to the multiplier on A; and against the number to be multiplied on B is the product on A.

Multiply 6 by 4.

Set 1 on B to 4 on A; and against 6 on B is 24 on A.

The slide thus set, against 7 on B is 28 on A.

8	"	32	"	
9	"	36	"	
10	"	40	"	
12	"	48	"	
15	"	60	"	
25	"	100	"	etc.

To Divide Numbers upon the Rule.

Set the divisor on B to 1 on A; and against the number to be divided on B is the quotient on A.

Divide 63 by 3.

Set 3 on B to 1 on A; and against 63 on B is 21 on A.

Proportion, or Rule of Three Direct.

RULE. — Set the first term on B to the second on A; and against the third upon B is the fourth upon A.

1. If 4 yards of cloth cost 38 cents, what will 30 yards cost at the same rate?

Set 4 on B to 38 on A; and against 30 on B is 285 cents on A.

2. Suppose I pay 31 dollars 50 cents for 3 cwt. of copper, at what rate is that per ton? 1 *ton* = 20 *cwt.*

Set 3 upon B to 31.5 upon A; and against 20 upon B is 210 upon A.

Rule of Three Inverse.

RULE. — Invert the slide, and the operation is the same as direct proportion.

1. I know that six men are capable of performing a certain given portion of work in eight days, but I want the same performed in three; how many men must there be employed?

Set 6 upon C to 8 upon A; and against 3 upon C is 16 upon A.

2. The lever of a safety-valve is 20 inches in length, and 5 inches between the fixed end and centre of the valve; what weight must there be placed on the end of the lever to equipoise a force or pressure of 40 lbs. tending to raise the valve?

Set 5 upon C to 40 upon A; and against 20 upon C is 10 upon A.

3. If $8\frac{3}{4}$ yards of cloth, $1\frac{1}{2}$ yard in width, be a sufficient quantity, how much will be required of that which is only $\frac{7}{8}$ths in width, to effect the same purpose?

Set 1·5 upon C to 8·75 upon A; and against 8·75 upon C is 15 yards upon A.

Square and Cube Roots of Numbers.

On the engineer's rule, when the lines C and D are equal at both ends, C is a table of squares, and D a table of roots, as

Squares	1	4	9	16	25	36	49	64	81	on C.
Roots	1	2	3	4	5	6	7	8	9	on D.

To find the Geometrical mean Proportion between two Numbers.

Set one of the numbers upon C to the same number upon D; and against the other number upon C is the mean number or side of an equal square upon D.

Required the mean proportion between 20 and 45.

Set 20 upon C to 20 upon D; and against 45 upon C is 30 upon D.

To cube any number, set the number upon C to 1 or 10 upon D; and against the same number upon D is the cube number upon C.

Required the cube of 4.

Set 4 upon C to 1 or 10 upon D; and against 4 upon D is 64 upon C.

To extract the cube root of any number, invert the slide, and set the number upon B to 1 or 10 upon D; and where two numbers of equal value coincide on the lines B D, is the root of the given number.

Required the cube root of 64.

Set 64 upon B to 1 or 10 upon D; and against 4 upon B is 4 upon D, or root of the given number.

On the common rule, when 1 in the middle of the line C is set opposite to 10 on D, then C is a table of squares, and D a table of roots.

To cube any number by this rule, set the number upon C to 10 upon D; and against the same number upon D is the cube upon C.

Mensuration of Surface.

1. *Squares, Rectangles, etc.*

RULE.—When the length is given in feet and the breadth in inches, set the breadth on B to 12 on A; and against the length on A is the content in square feet on B.

If the dimensions are all inches, set the breadth on B to 144 upon A; and against the length upon A is the number of square feet on B.

Required the content of a board 15 inches broad and 14 feet long.

Set 15 upon B to 12 upon A; and against 14 upon A is 17·5 square feet on B.

2. *Circles, Polygons, etc.*

RULE.—Set ·7854 upon C to 1 or 10 upon D; then will the lines C and D be a table of areas and diameters.

Areas	3·14	7·06	12·56	19·63	28·27	38·48	50·26	63·61	upon C.
Diam.	2	3	4	5	6	7	8	9	upon D.

In the common rule, set ·7854 on C to 10 on D; then C is a line or table of areas, and D of diameters, as before.

Set 7 upon B to 22 upon A; then B and A form or become a table of diameters and circumferences of circles.

Cir.	3·14	6·28	9·42	12·56	15·7	18·85	22	25·13	28·27 upon A.
Dia.	1	2	3	4	5	6	7	8	9 upon B.

Polygons from 3 to 12 sides.—Set the gauge-point upon C to 1 or 10 upon D; and against the length of one side upon D is the area upon C.

Sides	3	5	6	7	8	9	10	11	12.
Gauge-points	·433	1·7	2·6	3·63	4·82	6·18	7·69	9·37	11·17.

Required the area of an equilateral triangle, each side 12 inches in length.

Set ·433 upon C to 1 upon D; and against 12 upon D are 62·5 square inches upon C.

Table of Gauge-Points for the Engineer's Rule.

NAMES.	F, F, F.	F, I, I.	I, I, I.	F, I.	I, I.	F.	I.
Cubic inches..	578	83	1728	106	1273	105	121
Cubic feet.....	1	144	1	1833	22	121	33
Imp. gallons..	163	231	277	294	353	306	529
Water in lbs.	16	23	276	293	352	305	528
Gold "	814	1175	141	149	178	155	269
Silver "	15	216	261	276	334	286	5
Mercury "	118	169	203	216	258	225	389
Brass "	193	177	333	354	424	369	637
Copper "	18	26	319	331	397	345	596
Lead "	141	203	243	258	31	27	465
Wro't iron "	207	297	357	338	453	394	682
Cast iron "	222	32	384	407	489	424	733
Tin "	219	315	378	401	481	419	728
Steel "	202	292	352	372	448	385	671
Coal "	127	183	22	33	28	242	42
Marble "	591	85	102	116	13	113	195
Freestone "	632	915	11	1162	14	141	21

For the Common Slide Rule.

NAMES.	F, F, F.	F, I, I.	I, I, I.	F, I.	I, I.	F.	I.
Cubic inches..	36	518	624	660	799	625	113
Cubic feet.....	625	9	108	114	138	119	206
Water in lbs.	10	144	174	184	22	191	329
Gold "	507	735	88	96	118	939	180
Silver "	938	136	157	173	208	173	354
Mercury "	738	122	127	132	162	141	242
Brass "	12	174	207	221	265	23	397
Copper "	112	163	196	207	247	214	371
Lead "	880	126	152	162	194	169	289
Wro't iron "	129	186	222	235	283	247	423
Cast iron "	139	2	241	254	304	265	458
Tin "	137	135	235	25	300	261	454
Steel "	136	183	22	233	278	239	418
Coal "	795	114	138	146	176	151	262
Marble "	370	53	637	725	81	72	121
Freestone "	394	57	69	728	873	755	132

Mensuration of Solidity and Capacity.

General Rule. — Set the length upon B to the gauge-point upon A; and against the side of the square, or diameter on D, are the cubic contents, or weight in lbs. on C.

1. Required the cubic contents of a tree 30 feet in length, and 10 inches quarter girt.

Set 30 upon B to 144 (the gauge-point) upon A; and against 10 upon D is 20·75 feet upon C.

2. In a cylinder 9 inches in length, and 7 inches diameter, how many cubic inches?

Set 9 upon B to 1273 (the gauge-point) upon A; and against 7 on D is 346 inches on C.

3. What is the weight of a bar of cast iron 3 in. square and 6 ft. long?

Set 6 upon B to 32 (the gauge-point) upon A; and against 3 upon D is 168 pounds upon C.

By the Common Rule.

4. Required the weight of a cylinder of wrought iron 10 inches long and 5½ diameter.

Set 10 upon B to 283 (the gauge-point) upon A; and against 5½ upon D is 66·65 pounds on C.

5. What is the weight of a dry rope 25 yards long and 4 inches circumference?

Set 25 upon B to 47 (the gauge-point) upon A; and against 4 on D is 53·16 pounds on C.

6. What is the weight of a short-linked chain 30 yards in length, and $\frac{6}{16}$ of an inch in diameter?

Set 30 upon B to 52 (the gauge-point) upon A; and against 6 on D is 129·5 pounds on C.

Power of Steam Engines.

Condensing Engines. Rule. — Set 3·5 on C to 10 on D; then D is a line of diameters for cylinders, and C the corresponding number of horses' power; thus,

H. Pr.	3½	4	5	6	8	10	12	16	20	25	30	40	50 on C.
C. D.	10 in.	10¾	12	13¼	15½	17	18¾	21½	24	26¾	29½	33¾	37¾ on D.

The same is effected on the common rule by setting 5 on C to 12 on D.

Non-condensing Engines. Rule. — Set the pressure of steam in pounds per square inch on B to 4 upon A; and against the cylinder's diameter on D is the number of horses' power upon C.

Required the power of an engine, when the cylinder is 20 inches diameter and steam 30 pounds per square inch.

Set 30 on B to 4 on A; and against 20 on D is 30 horses' power on C.

The same is effected on the common rule by setting the force of the steam on B to 250 on A.

Of Engine Boilers.

How many superficial feet are contained in a boiler 23 feet in length and 5½ feet in width?

Set 1 on B to 23 on A; and against 5·5 upon B is 126·5 square feet upon A.

If 5 square feet of boiler surface be sufficient for each horse-power, how many horses' power of engine is the boiler equal to?

Set 5 upon B to 126·5 upon A; and against 1 upon B is 25·5 upon A.

Horse Power.

As this is the universal term used to express the capability of first movers, of magnitude, it is essential that the estimate of it should be uniform.

Its estimate is the elevation of 33,000 pounds avoirdupois one foot in height in one minute, and it is designated as being Nominal, Indicated, or Actual.

The first designation being adopted and referred to by Manufacturers of steam engines in order to express the capacity of an engine, the elements thereof being confined to the dimensions of the steam cylinder, and a conventional pressure of steam and speed of piston; the second to designate the full capacity of an engine, as developed in operation, without any deduction for friction; and the last referring to its actual power as developed by its operation, involving the elements of the mean pressure upon the piston, its velocity, and a just deduction for the friction of the operation of the machine.

In reviewing the various modes for the computation as submitted by Engineers and Manufacturers, there is no proper formula that presents the essential element of being in conformity with any other, and as conformity in a rule for this purpose, if based upon an assimilation to the capacity of an engine, is all that is requisite, it would have been preferable to have adopted an existing formula to the introduction of a new one, had it been practicable to have done so. It occurs, further, that there is not only a want of conformity in the various rules essayed by authors, but they have neither reached the cases of both condensing and non-condensing engines, nor have they properly approached to the actual power of an engine; and as the practice of operating engines since the adoption of existing formulæ has materially altered, both in an increase of pressure and velocity of piston, the following rules are submitted.

Nominal Horse's Power.

CONDENSING ENGINE.

$\frac{d^2\, v}{3000}$ = *horse's power; d representing diam. of cylinder in inches, and v the velocity of the piston in feet per minute.*

This is alike to the rule of the British Admiralty, substituting 3000 for 6000, and it is based upon a uniform steam pressure of 10 lbs. per square inch (steam gauge, or *above* the pressure of the atmosphere), cut off at one-half the stroke, deducting one-fifth*

* The friction and losses in a marine engine may be taken at 1·5 to 2 lbs. per square inch for working the engine, and 5 to 7½ per cent. upon the remainder for the friction of the load.

for friction and losses, with a mean velocity of piston of 250 feet per minute for an engine of long stroke, and of 200 feet for one of short stroke.

The rule of the British Admiralty is based upon a uniform and effective pressure of 7 lbs. per square inch at full stroke, and a mean velocity of piston of 205 feet per minute: viz., 170 feet for a stroke of 2·5 feet, and 240 feet for a stroke of 8 feet.

NON-CONDENSING ENGINE.

$$\frac{d^2\, v}{1000} = \textit{horse's power.}$$

This is based upon a uniform steam pressure of 60 lbs. per square inch (steam gauge), cut off at one-half the stroke, deducting one-sixth for friction and losses, with a mean velocity of piston of 250 feet per second.

Nominal Horse Power of several Non-condensing Engines.

Computed from Formula $\frac{d^2\, v}{1000} = \text{H. P.}$

Horses' Power.	Diameter and Stroke of Cylinder.		Revolutions.	Horses' Power.	Diameter and Stroke of Cylinder.		Revolutions.	Horses' Power.	Diameter and Stroke of Cylinder.		Revolutions.
No.	Ins.	Feet.	Min.	No.	Ins.	Feet.	Min.	No.	Ins.	Feet.	Min.
9·	6×	1·	125	46·1	12×	4·5	32	159·7	22×	5·5	30
9·2	6	1·5	85	55·3	14	3·	47	160·7	22	6·	28
12·2	7	1·	125	56·3	14	3·5	41	163·6	22	6·5	26
12·5	7	1·5	85	58·	14	4·	37	169·4	22	7·	25
16·3	8	1·5	85	60·	14	4·5	34	183·7	24	5·5	29
16·9	8	1·75	75	60·8	14	5·	30	193·5	24	6·	28
21.1	9	1·5	87	64·8	15	3·	48	194·7	24	6·5	26
21·3	9	1·75	75	66·1	15	3·5	42	193·5	24	7·	24
21·4	9	2.	66	66·6	15	4·	37	198·7	24	7·5	23
21·5	9	2·5	53	66·8	15	4·5	33	227·1	26	6·	28
26·1	10	1·5	87	67·5	15	5·	30	228·5	26	6·5	26
26.6	10	1·75	76	77·1	16	3·5	43	227·1	26	7.	24
27·2	10	2·	68	77·8	16	4·	38	233·2	26	7·5	23
27·5	10	2·5	55	78·3	16	4·5	34	237·9	26	8·	22
28·2	10	3·	47	79·4	16	5·	31	266·	28	6·5	26
28·7	10	3·5	41	81·7	16	5·5	29	274·4	28	7·	25
28·8	10	4·	36	82·9	16	6·	27	270·5	28	7·5	23
32·9	11	2·	70	99·1	18	4·5	34	275·8	28	8·	22
33·3	11	2·5	55	103·7	18	5·	32	279·9	28	8·5	21
33.4	11	3.	46	103·4	18	5·5	29	304·2	30	6·5	26
33.9	11	3·5	40	105·	18	6·	27	315·	30	7·	25
34·9	11	4.	36	128.	20	5·	32	324·	30	7·5	24
39·2	12	2·	68	127.6	20	5·5	29	331·2	30	8·	23
39·6	12	2·5	55	129·6	20	6·	27	336·6	30	8·5	22
40·6	12	3·	47	130·	20	6·5	25	340·2	30	9·	21
41·3	12	3·5	41	134·4	20	7·	24	359·1	30	9·5	21
41·5	12	4.	36	154·9	22	5·	32	360·	30	10·	20

Indicated Horse Power.

This is the gross power exerted by an engine, without any deduction for friction, the mean pressure upon the piston being determined by an Indicator, or by a computation based upon the actual initial pressure in the cylinder.

Mixture of Air and Steam.

Water contains a portion of air or other uncondensable gaseous matter, and when it is converted into steam, this air is mixed with it, and when the steam is condensed it is left in a gaseous state. If means were not taken to remove this air or gaseous matter from the condenser of a steam-engine, it would fill it and the cylinder, and obstruct their operation; but, notwithstanding the ordinary means of removing it (by the air-pump), a certain quantity of it always remains in the condenser.

20 volumes of water absorb 1 volume of air.

Steam Acting Expansively.

To Compute the mean Pressure of Steam upon a Piston by Hyperbolic Logarithms.

Rule.— Divide the length of the stroke of a piston, added to the clearance in the cylinder at one end, by the length of the stroke at which the steam is cut off, added to the clearance at that end, and the quotient will express the relative expansion of the steam or *number*.

Find in the table the logarithm of the *number* nearest to that of the quotient, to which add 1. The sum is the ratio of the gain.

Multiply the ratio thus obtained by the pressure of the steam (including the atmosphere) *as it enters the cylinder*, divide the product by the relative expansion, and the quotient will give the mean pressure required.

Table of Hyperbolic Logarithms.

No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1·05	·049	2.65	·975	4·25	1·447	5·8	1·758	7·4	2·001
1·1	·095	2·66	·978	4·3	1·459	5·85	1·766	7·45	2·008
1·15	·14	2·7	·993	4·33	1·465	5·9	1·775	7·5	2 015
1·2	·182	2·75	1·012	4·35	1·47	5·95	1·783	7·55	2·022
1·25	·223	2·8	1·03	4·4	1·482	6·	1·792	7·6	2·028
1·3	·262	2·85	1·047	4·45	1·493	6·05	1·8	7·65	2·035
1·33	·285	2·9	1·065	4·5	1·504	6·1	1·808	7·66	2·036
1·35	·3	2·95	1·082	4·55	1·515	6·15	1·816	7·7	2·041
1·4	·336	3·	1·099	4·6	1·526	6·2	1·824	7·75	2·048
1·45	·372	3·05	1·115	4·65	1·537	6·25	1·833	7·8	2·054
1·5	·405	3·1	1·131	4·66	1·54	6·3	1·841	7·85	2·061
1·55	·438	3·15	1·147	4·7	1·548	6·33	1·845	7·9	2·067
1·6	·47	3·2	1·163	4·75	1·558	6·35	1·848	7·95	2·073
1·65	·5	3·25	1·179	4·8	1·569	6·4	1·856	8·	2·079
1·66	·506	3·3	1·194	4·85	1·579	6·45	1·864	8·05	2·086
1·7	·531	3·33	1·202	4·9	1·589	6·5	1·872	8·1	2·092
1·75	·56	3·35	1·209	4·95	1·599	6·55	1·879	8·15	2·098
1·8	·588	3·4	1·224	5·	1·609	6·6	1·887	8·2	2·104
1·85	·612	3·45	1·238	5·05	1·619	6·65	1·895	8·25	2·11
1·9	·642	3·5	1·253	5·1	1·629	6·66	1·896	8·3	2·116
1·95	·668	3·55	1·267	5·15	1·639	6·7	1·902	8·33	2·119
2·	·693	3·6	1·281	5·2	1·649	6·75	1·91	8·35	2·122
2·05	·718	3·65	1·295	5·25	1·658	6·8	1·917	8·4	2·128
2·1	·742	3·66	1·297	5·3	1·668	6·85	1·924	8·45	2·134
2·15	·765	3·7	1·308	5·33	1·673	6·9	1·931	8·5	2·14
2·2	·788	3·75	1·322	5·35	1·677	6·95	1·939	8·55	2·146
2·25	·811	3·8	1·335	5·4	1·686	7·	1·946	8·6	2·152
2·3	·833	3·85	1·348	5·45	1·696	7·05	1·953	8·65	2·158
2·33	·845	3·9	1·361	5·5	1·705	7·1	1·96	8·66	2·159
2·35	·854	3·95	1·374	5·55	1·714	7·15	1·967	8·7	2·163
2·4	·875	4·	1·386	5·6	1·723	7·2	1·974	8·75	2·169
2·45	·896	4·05	1·399	5·65	1·732	7·25	1·981	8·8	2·175
2·5	·916	4·1	1·411	5·66	1·733	7·3	1·988	8·85	2·18
2·55	·936	4·15	1·423	5·7	1·74	7·33	1·991	8·9	2·186
2·6	·956	4·2	1·435	5·75	1·749	7·35	1·995	8·95	2·192

NOTE.—The Hyp. Log. of any number not in the table may be found by multiplying a common log. by 2·302585053, usually by 2·3.

Example.—Assume steam to enter a cylinder at a pressure of 34·7 lbs. per square inch, and to be cut off at $\frac{1}{4}$ the length of the stroke of the piston, the stroke being 10 feet; what will be the mean pressure?

10 feet + ·5 for clearance = 120·5 *ins.*, stroke 10 ÷ 4 + ·5 for clearance = 30·5 *ins.*

Then 120·5 ÷ 30·5 = 3·95, *the relative expansion.*

Log. of number 3·95 = 1·374, which + 1 = 2·374.

$$\frac{2{\cdot}374 \times 34{\cdot}7}{3{\cdot}95} = \frac{82{\cdot}3778}{3{\cdot}95} = 20{\cdot}855 \text{ } lbs.$$

When the Relative Expansion or Number falls between two numbers in the Table, proceed as follows: Take the difference between the logs. of the two numbers. Then, as the difference between the numbers is to the difference between these logs., so is the excess of the expansion over the least number, which, added to the least log., will give the log. required.

ILLUSTRATION. — The expansion is 4·84, the logs. for 4·8 and 4·85 are 1·569 and 1·579, and their difference ·01. Hence, as 4·85 ∽ 4·8 = ·05 : 1·579 ∽ 1·569 = ·01 : : 4·84 — 4·8 = ·04 : ·008, and 1·569 + ·008 = 1·577 = *the log. required.*

Effect of Expansion with Equal Volumes of Steam.

The theoretical economy of using steam expansively is as follows — a like volume of steam being expended in each case, and expanded to fill the increased spaces.

Point of Cutting Off.	Expansion Number.	Mean Pressure of Steam.	Gain per Cent. in Power.	Point of Cutting Off.	Expansion Number.	Mean Pressure of Steam.	Gain per Cent. in Power.
·1	10·	3·302	230·	·5	2·	1·693	69·3
·125	8·	3·079	208·	·6	1·66	1·507	50·7
·166	6·	2·791	179·	·625	1·6	1·47	47·
·2	5.	2·609	161·	·666	1·5	1·405	40·5
·25	4·	2·386	139·	·7	1·42	1·351	35·1
·3	3·33	2·203	120·	·75	1·33	1·285	22·3
·333	3·	2·099	110·	·8	1·25	1·223	20·5
·375	2.66	1·978	97·8	·875	1·143	1·131	13·1
·4	2·5	1·916	91·6	·9	1·11	1·104	10·4

In this illustration, no deductions are made for a reduction of the temperature of the steam while expanding or for loss by back pressure.

The same relative advantage follows in expansion as above given, whatever may be the initial pressure of the steam.

Gain in Fuel, and Initial Pressure of Steam required, when acting Expansively, compared with Non-Expansion or Full Stroke.

Point of Cutting Off.	Gain in Fuel.	Initial Pressure Required.		Point of Cutting Off.	Gain in Fuel.	Initial Pressure Required.	
		Cutting Off.	Full Stroke.			Cutting Off.	Full Stroke.
Stroke.	Per Cent.	Lbs.	Lbs.	Stroke.	Per Cent.	Lbs.	Lbs.
$\frac{7}{8}$	11·7	1·01	1·	$\frac{3}{8}$	49·6	1·32	1·
$\frac{3}{4}$	22·4	1·03	1·	$\frac{1}{4}$	58·2	1·67	1·
$\frac{5}{8}$	32·	1·09	1·	$\frac{1}{8}$	67·6	2·6	1·
$\frac{1}{2}$	41·	1·18	1·				

The *Relative Effect* of Steam during Expansion is obtained from the preceding rule.

The *Mechanical Effect* of Steam in a cylinder is the product of the mean pressure in lbs., and the distance through which it has passed in feet.

The *Pressure at the End of a Stroke*, or *at any Given Point of the Stroke*, is obtained by dividing the initial pressure by the portion of the stroke performed when the steam is cut off.

Slide-Valves.

All Dimensions in Inches.

To Compute how much Lap must be given on the Steam Side of a Slide-Valve to cut off the Steam at any given Part of the Stroke of the Piston.

Rule.—From the length of stroke of piston subtract the length of the stroke that is to be made before the steam is cut off; divide the remainder by the stroke of the piston, and extract the square root of the quotient. Multiply this root by half the throw of the valve, from the product subtract half the lead, and the remainder will give the lap required.

Example.—Having stroke of piston 60 inches, stroke of valve 16 inches, lap upon exhaust side $\frac{1}{2}$ inch $= \frac{1}{32}$ of valve stroke, lap upon steam side $3\frac{1}{4}$ inches, lead 2 inches, steam to be cut off at $\frac{5}{6}$ the stroke; what is the lap?

$$60 - \frac{5}{6} \text{ of } 60 = 10 \cdot \quad \frac{10}{16} = \cdot 166. \quad \sqrt{\cdot 166} = 408. \quad \cdot 408 \times \frac{16}{2} = 3 \cdot 264,$$

and $3 \cdot 264 - \frac{2}{2} = 2 \cdot 264$ *inches or the lap — half the lead.*

To Compute the Lap required on the Steam Side of a Valve, to cut the Steam off at various Portions of the Stroke of the Piston.

Valve without Lead.

	Distance of the piston from the end of its stroke when the steam is cut off, in parts of the length of its stroke.									
	$\frac{1}{2}$	$\frac{5}{12}$	$\frac{1}{3}$	$\frac{7}{24}$	$\frac{1}{4}$	$\frac{5}{24}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$	$\frac{1}{24}$
Lap in parts of the stroke....	·354	·323	·286	·27	·25	·228	·204	·177	·144	·102

Illustration.—Take the elements of the preceding case.

Under $\frac{1}{6}$ is ·204, and $\cdot 204 \times 16 = 3 \cdot 264$ *inches lap.*

When the Valve is to have Lead.—Subtract half the proposed lead from the lap ascertained by the table, and the remainder will be the proper lap to give to the valve.

If, therefore, as in the last case, the valve was to have 2 inches lead, then $2 \div 2 - 3 \cdot 264 = 2 \cdot 264$ *inches.*

Portion of the Stroke of a Piston at which the Exhausting Port is closed and opened.

Lap on the Exhaust Side of the Valve in Parts of its throw.

Lap.	Portion of Stroke at which the Steam is cut off.							
	$\frac{1}{3}$	$\frac{7}{24}$	$\frac{1}{4}$	$\frac{5}{24}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$	$\frac{1}{24}$
A								
$\frac{1}{8}$	·178	·161	·143	·126	·109	·093	·074	·053
$\frac{1}{16}$	·13	·118	·1	·085	·071	·058	·043	·027
$\frac{1}{32}$	·113	·101	·085	·069	·053	·043	·033	·024
0	·092	·082	·067	·055	·041	·033	·022	·011
B								
$\frac{1}{8}$	·033	·026	·019	·012	·008	·004	·001	·001
$\frac{1}{16}$	·06	·052	·04	·03	·022	·015	·008	·002
$\frac{1}{32}$	·073	·066	·051	·042	·033	·023	·013	·004
0	·092	·082	·067	·055	·044	·033	·022	·011

The units in the columns of the table marked A express the distance of the piston, in parts of its stroke, from the end of the stroke when the exhaust port in advance of it is closed; and those in the columns of the table marked B express the distance of the piston, in parts of its stroke, from the end of its stroke when the exhaust port behind it is opened.

ILLUSTRATION.—A slide-valve is to cut off at $\frac{1}{6}$ from the end of the stroke of the piston, the lap on the exhaust side is $\frac{1}{32}$ of the stroke of the valve (16 inches), and the stroke of the piston is 60 inches. At what point of the stroke of the piston will the exhaust port in advance of it be closed, and the one behind it opened?

Under $\frac{1}{6}$ in table A, opposite to $\frac{1}{32}$, is ·053, which $\times$ 60, the length of the stroke = 3·18 *inches;* and under $\frac{1}{6}$ in table B, opposite to $\frac{1}{32}$, is ·033, which $\times$ 60 = 1·98 *inches.*

If the lap on the exhaust side of this valve was increased, the effect would be to cause the port in advance of the valve to be closed sooner, and the port behind it opened later. And if the lap on the exhaust side was removed entirely, the port in advance of the piston would be shut, and the one behind it open, at the same time.

The lap on the steam side should always be greater than that on the exhaust side, and the difference greater the higher the velocity of the piston.

In fast-running engines alike to locomotives, it is necessary to open the exhaust valve before the end of the stroke of the piston, in order to give more time for the escape of the steam.

To Ascertain the Breadth of the Ports.

Half the throw of the valve should be at least equal to the lap on the steam side, added to the breadth of the port. If this

breadth does not give the required area of port, the throw of the valve must be increased until the required area is attained.

To Compute the Stroke of a Slide-Valve.

RULE.—To twice the lap add twice the width of a steam port in inches, and the sum will give the stroke required.

Expansion by lap, with a slide-valve operated by an eccentric alone, cannot be extended beyond $\frac{1}{3}$ of the stroke of a piston without interfering with the efficient operation of the valve; with a link motion, however, this distortion of the valve is somewhat compensated. When the lap is increased, the throw of the eccentric should also be increased.

When low expansion is required, a cut-off valve should be resorted to in addition to the main valve.

To Compute the Lap and Lead of Locomotive Valves.

$\cdot 32\, t =$ *lap in inches*, and $\cdot 07\, t =$ *lead in inches; t representing the stroke of the valve.*

Giffard's Injector.

Maximum Temperature of the Feed-water Admissible at different Pressures of Steam.

	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Pressure per square inch...	10	20	30	40	50	100
Temperature of feed.........	148°	138°	130°	124°	120°	110°

The capacities of injectors are denoted by the diameters of their *throats* in millimetres; thus No. 4 has a diameter of 4 millimetres $= 4 \times \cdot 0394 = \cdot 1576$ *inches.*

The expenditure of steam increases with the proportionate pressure in the boiler.

Raising the Safety-Valve of a Boiler will lessen the pressure by allowing the steam to escape from the boiler, thus permitting the water to rise up and come in contact with the over-heated iron, and probably cause an explosion.

The Door and Damper should never be open at the same time, unless it is absolutely necessary, as the cold air, that would otherwise have to pass through the fire and become rarified, rushes through the open door above the fire, and impinges on the tube and crown-sheets, and has a tendency to contract the seams and cause them to leak.

Blowing out the Boiler under a high steam pressure, the change is so sudden that it has a tendency to contract the iron, and cause the boiler to leak.

To heat Rooms, 1 square foot of steam-pipe surface is required for 80 cubic feet of space; 1 cubic foot of boiler is required for 1500 cubic feet of space. One horse-power boiler is sufficient for 40,000 cubic feet of space.

BELTS.

The resistance of belts to slipping is independent of their breadth, consequently there is no advantage derived in increasing this dimension beyond that which is necessary to enable the belt to resist the strain it is subjected to.

The ratio of friction to pressure for belts over wood drums, is, for leather belts, when worn, ·47; when new, ·5; and when over turned cast-iron pulleys, ·24 and ·27.

A leather belt will safely and continuously resist a strain of 350 lbs. per square inch of section, and a section of ·2 of a square inch will transmit the equivalent of a horse's power at a velocity of 1000 feet per minute over a wooden drum, and ·4 of a square inch over a turned cast-iron pulley.

A vulcanized India-rubber belt will sustain a greater stress than leather, added to which its resistance to slipping is from 50 to 85 per cent. greater.

In high speed belting, the tension, or the breadth of the belt, should be increased, in order to prevent the belt from slipping. Long belts are more effective than short ones.

To Compute the Stress a Belt or Cord is capable of transmitting.— *Aide Memoire.*

Rule.— Multiply the *value* of C from the following table by the stress in pounds.

Proportion of Arc embraced to the Circumference of the Driving Pulley.	Value of Coefficient C.			
	Leather Belts.		Cords on Wooden Sheaves.	
	On Wood Drums.	On Iron Pulleys.	Rough.	Polished.
·2	1·8	1·4	1·9	1·5
·3	2·4	1·7	2·6	1·9
·4	3·3	2·	3·5	2·3
·5	4·4	2·4	4·8	2·8
·6	5·9	2·9	6·6	3·5
·7	7·9	3·4	9·	4·2

C = *the ratio of the resistance of a drum or pulley to slipping a belt or cord when the resistance of the belt or cord upon the under or slack side is known.*

Example.— What is the stress a belt is capable of transmitting when the arc embraced upon the surface of the driving and wooden drums is ·4 of its circumference, and the power or tension of the belt is 200 lbs.?

$$3{\cdot}3 \times 200 = 660 \textit{ lbs.}$$

To Compute the Stress which is transmitted to a Belt or Cord.

RULE.— Divide the power in pounds transmitted to the periphery of the pulley by the velocity of the surface of the drum.

Example.— A cast-iron pulley, 4 feet in diameter, driven by a power of four horses, makes 100 revolutions per minute; what is the stress upon the belt?

$33{,}000 \times 4 = 132{,}000$ *lbs.* 1 *foot per minute.*

$4 \times 3{\cdot}1416 \times 100 = 1256{\cdot}64$ *feet velocity.*

Then $\frac{132000}{1256{\cdot}64} = 105$ *lbs.* = *difference of the stress upon the belt and the resistance of the under side of it,* $\frac{S}{C-1} = S$, and $S + s = P$. P *representing the stress transmitted by a belt,* s *the resistance of its under side,* and P *the sum of* $S + s$, *or the stress and resistance.*

ILLUSTRATION.— What should be the resistance of the under side of a leather belt running over the semi-circumference of a cast-iron pulley, 1 foot in diameter, driven by a power of 200 lbs.?

$$\frac{200}{2{\cdot}4 - 1} = 142{\cdot}85 \textit{ lbs.}$$

LIMES, CEMENTS, MORTARS, AND CONCRETES.

Turkish Plaster, or Hydraulic Cement.—100 lbs. fresh lime reduced to powder, 10 quarts linseed-oil, and 1 to 2 ounces cotton. Manipulate the lime, gradually mixing the oil and cotton, in a wooden vessel, until the mixture becomes of the consistency of bread-dough.

Dry, and, when required for use, mix with linseed oil to the consistency of paste, and then lay on in coats. Water-pipes of clay or metal, joined or coated with it, resist the effect of humidity for very long periods.

Exterior Plaster or Stucco.— 1 volume of cement powder to 2 volumes of dry sand.

In India, to the water for mixing the plaster is added 1 lb. of sugar, or molasses, to 8 Imperial gallons of water, for the first coat; and for the second or finishing, 1 lb. sugar to 2 gallons water.

Powdered slaked lime and Smith's forge scales, mixed with blood in suitable proportions, make a moderate hydraulic mortar, which adheres well to masonry previously coated with boiled oil.

The plaster should be applied in two coats laid on in one operation, the first coat being thinner than the second. The second coat is applied upon the first while the latter is yet soft.

The two coats should form one of about 1½ inches in thickness, and when finished it should be kept moist for several days.

This process may be modified by substituting for the first coat a wash of thick cream of pure cement, applied with a stiff brush just before the plaster is laid on.

When the cement is of too dark a color for the desired shade, it may be mixed with white sand in whole or in part, or lime paste may be added until its volume equals that of the cement paste.

Khorasmar, or Turkish Mortar, used for the construction of buildings requiring great solidity, $\frac{1}{3}$ powdered brick and tiles, $\frac{2}{3}$ fine sifted lime. Mix with water to the required consistency, and lay on layers of 5 and 6 inches in thickness between the courses of brick or stones.

Interior Plastering.— The mortars used for inside plastering are termed Coarse, Fine, Gauge or hard finish, and Stucco.

Coarse Stuff. — Common lime mortar, as made for brick masonry, with a small quantity of hair; or by volumes, lime paste (30 lbs. lime) 1 part, sand 2 to $2\frac{1}{4}$ parts, hair $\frac{1}{6}$ part.

When full time for hardening cannot be allowed, substitute from 15 to 20 *per cent.* of the lime by an equal proportion of hydraulic cement.

For the second or *brown coat* the proportion of hair may be slightly diminished.

Fine Stuff (lime putty). — Lump lime slaked to a paste with a moderate volume of water, and afterwards diluted to the consistency of cream, and then to harden by evaporation to the required consistency for working.

In this state it is used for a *slipped coat*, and when mixed with sand or plaster of Paris, it is used for the *finishing coat.*

Gauge Stuff, or Hard finish, is composed of from 3 to 4 volumes fine stuff and 1 volume plaster of Paris, in proportions regulated by the degree of rapidity required in hardening; for cornices, etc., the proportions are equal volumes of each, fine stuff and plaster.

Stucco is composed of from 3 to 4 volumes of white sand, to 1 volume of fine stuff, or lime putty.

Scratch Coat.— The first of three coats when laid upon laths, and is from $\frac{1}{4}$ to $\frac{3}{8}$ of an inch in thickness.

One-coat Work.—Plastering in one coat without finish, either on masonry or laths — that is, *rendered* or *laid.*

Two-coat Work.— Plastering in two coats is done either in a *laying coat and set*, or in a *screed coat and set.*

The **Screed coat** is also termed a *Floated coat. Laying* the first coat in two-coat work is resorted to in common work instead of *screeding*, when the finished surface is not required to be exact to a straight-edge. It is laid in a coat of about $\frac{1}{2}$ an inch in thickness.

The laying coat, except for very common work, should be *hand-floated.*

The firmness and tenacity of plastering is very much increased by hand-floating.

Screeds are strips of mortar 6 to 8 inches in width, and of the required thickness of the first coat, applied to the angles of a room, or edge of a wall and parallelly, at intervals of 3 to 5 feet over the surface to be covered. When these have become sufficiently hard to withstand the pressure of a straight-edge, the inter-spaces between the screeds should be filled out flush with them, so as to produce a continuous and straight, even surface.

Slipped Coat is the smoothing off of a brown coat with a small quantity of lime putty, mixed with 3 per cent. of white sand, so as to make a comparatively even surface.

This finish answers when the surface is to be finished in distemper, or paper.

Hard Finish.— Fine stuff applied with a trowel to the depth of about $\frac{1}{8}$ of an inch.

Estimate of Materials and Labor for 100 Square Yards of Lath and Plaster.

Materials and Labor.	3 Coats Hard Finish.	Two Coats Slipped.	Materials and Labor.	3 Coats Hard Finish.	Two Coats Slipped.
Lime	4 casks.	$3\frac{1}{2}$ casks.	White sand..	$2\frac{1}{2}$ bush.	
Lump lime..	$\frac{2}{3}$ "		Nails..........	13 lbs.	13 lbs.
Plast. Paris..	$\frac{1}{2}$ "		Masons	4 days.	$3\frac{1}{2}$ days.
Laths	2000.	2000.	Laborer	3 "	2 "
Hair...........	4 bush.	3 bush.	Cartage.......	1 "	$\frac{3}{4}$ "
Sand	7 loads.	6 loads.			

Hydraulic.— $1\frac{1}{2}$ parts unslacked hydraulic lime, $1\frac{1}{2}$ parts sand, 1 part gravel, and 2 parts of a hard broken limestone.

This mass contracts one-fifth in volume. Fat lime may be mixed with concrete without serious prejudice to its hydraulic energy.

Various Compositions of Concrete.— Forts Richmond and Tompkins, U. S.

Hydraulic.— 308 lbs. cement = 3·65 to 3·7 cubic feet of stiff paste. 12 cubic feet of loose sand = 9·75 cubic feet of dense.

For Superstructure.— 11·75 cubic feet of mortar as above, and 16 cubic feet of stone fragments.

In the foundations of Fort Tompkins, about $\frac{1}{12}$ of its volume was composed of stones from $\frac{1}{4}$ to $\frac{3}{4}$ of a cubic foot in volume, rammed into the wall as the concrete was laid.

Sea Wall.— *Boston Harbor.*— *Hydraulic.*— 308 lbs. cement, 8 cubic feet of sand, and 30 cubic feet of gravel. The whole producing 32·3 cubic feet.

Superstructure.— 308 lbs. cement, 80 lbs. lime, and 14·6 cubic feet dense sands. The whole producing 12·825 cubic feet.

Cost of labor and materials expended in laying concrete foundation at Fort Tompkins, during the year 1849, per cubic yard as laid, $2.26.

Transverse Strength

Of Concretes, Cements, Mortars, Puzzuolana, and Trass, deduced from the Experiments of Generals Totten and Gillmore, U. S. A., General Treussart, and M. Voisin.

Reduced to a uniform Measure of One Inch Square and One Foot in Length. Supported at both Ends.

$\frac{2}{3}\frac{l\,W}{4\,b\,d^2} = V$ *per square inch of section, representing value for general use, being* $\frac{2}{3}$ *of ultimate breaking strain.*

Experiments of Voisin, 1857.

Mortar. One Volume of Sand. Cement.	Mortar. One Volume of Sand. Water.	Volume produced.	Concrete. One Volume of Pebbles. Mortar.	Concrete. One Volume of Pebbles. Volume produced.	Concrete. Value. 10 Days.	Concrete. Value. 60 Days.	Mortar. One Volume of Sand. Cement.	Mortar. One Volume of Sand. Water.	Volume produced.	Concrete. One Volume of Pebbles. Mortar.	Concrete. One Volume of Pebbles. Volume produced.	Concrete. Value. 10 Days.	Concrete. Value. 60 Days.
					Lbs.	Lbs.						Lbs.	Lbs.
1	·62	1·69	1	1·56	2·3	2·9	$\frac{1}{3}$	·38	1·12	$\frac{1}{2}$	1·03	·58	1·2
			$\frac{1}{2}$	1·03	1·7	3·2	$\frac{1}{4}$	·35	1·05	1	1·4	·48	1·
			$\frac{1}{3}$	1·	1·8	3·1				$\frac{1}{2}$	1·01	·35	·85
			$\frac{1}{4}$	1·	1·	1·	$\frac{1}{5}$	·34	1·	1	1·45	·3	·83
$\frac{1}{2}$	·43	1·24	1	1·45	1·6	2·7				$\frac{1}{2}$	1·03	·44	·65
			$\frac{1}{2}$	1·	1·	1·9	$\frac{1}{6}$	·32	·96	1	1·45	·41	·81
$\frac{1}{3}$	·83	1·12	1	1·4	·86	·91				$\frac{1}{2}$	1·03	·36	·79

Experiments of General Totten, 1837.

Concrete. *	Mortar. Cement 1.	Mortar. Cement 1. Sand ·5.	Mortar. Cement 1. Sand 1.	Concrete. *	Mortar. Cement 1.	Mortar. Cement 1. Sand ·5.	Mortar. Cement 1. Sand 1.
	Lbs.	Lbs.	Lbs.		Lbs.	Lbs.	Lbs.
Granite ..1 Mortar...1	2·9	2·4	2·3	Stone...... Gravel.....	1·9	1·	·6
Gravel ...1 Mortar...2	1·4	2·4	·7	Brick...... Gravel.....	·9	1·4	1·6

*·The granite, bricks, etc., were broken into fragments or spalls of the required size.

Tensile Strength

Of various Cements, Mortars, and Masonry, deduced from the Experiments of Vicat and Chatoney at Cherbourg, Gen. Gillmore, U. S. A., Crystal Palace, London, etc.

Weight or Power required to Tear asunder One Square Inch.

Materials and Mixtures.	Ultim. Resistance.	Materials and Mixtures.	Ultim. Resistance.
	Lbs.		Lbs.
Boulogne, 100 parts, water 50.......	112	Portland, English, 320 days, cement 1, sand 2.......	713
90 days, 100 parts, water 50..........	52		
Boulogne, 1 year, Portland (natural)	675	" 45 days, pure and mixed, stiff...........	206
English, 1 year, Portland (artificial)..........	462	" English, pure, 1 month	393
		" " " 6 mos....	421
Portland, 42 days, cement 1, sand 1	142	Roman, 1 year, from Septaria..	191
" 15 "	134	" 42 days, cement 1, sand 1	284
" 135 "	233	" " " 1, " 2	199
" English, 320 days, pure...	1152	" " " 1, " 3	166
" " " cement 1, sand 1,	948	Stonemasonry, Roman cement, 5 mos..............................	77

Brick and Granite Masonry, 320 Days.		Lbs.
Cement, Delafield and Baxter	Pure	68·56
	Cement ... 4, Sand ... 1	68·5
	Cement ... 5, Siftings ... 1	79·87
	Cement ... 1, Siftings ... 2	74·5
" Lawrence Co.	Pure	87·37
	Pure	53·68
" James River	Cement ... 4, Sand ... 1	62·
" Newark Lime and Cement Co.	Pure	93·25
	Cement ... 1, Sand ... 2	39·62
" Brighton and Rosendale	Pure	80·25
" Newark and Rosendale	Pure	75·81
" Pure upon bricks		31·
" 1, sand 1 pure upon bricks		16·
" 1, " 3 " "		7·
" Pure upon granite		27·
" 1, water ·5		20·
" 1, " ·42		27·
" Pure upon bricks, without mortar, mean		45·
Common lime ... 1, " sand ... 2½	"	6·
Lime paste ... 1, Sand ... 3	upon bricks	6·
Lime paste ... 1, Sand ... 2	"	4·13
Lime paste ... 1, Sand ... 3, Cement paste ... 5	"	11·41

Crushing Strength of Cements, Stone, etc.

(*Crystal Palace, London.*)

Reduced to a uniform Measure of One Square Inch.

Material.	Ultimate Pressure.	Material.	Ultimate Pressure.
	Lbs.		Lbs.
Portland cement, area 1, height 1	1680	Portland cement 1, " sand 4	1244
" cement, " sand	1244	Roman cement, pure	342

Experiments of General Gillmore.

Materials.	Cements and Mixtures.	Value.	Materials.	Cements and Mixtures.	Value.
		Lbs.			Lbs.
Delafield and Baxter..........	Stiff paste..........	6·*	Portland Pure (Eng.), 100 days	Cement 1, Sand ... 1	12·5, 13·
High Falls (N. Y.), 270 days..	Pure	11·3		Cement 1, Sand ... 2	8·5
James River.....	Cement.........., Sand..............	5·9	Roman (Eng.), 100 days..........	Cement 1, Sand ... 1	4·
James River, 59 days	Cement........ 4·, Water .... 2·6	1·9	Rosendale, 95 days	Pure	7·
	Cement........ 4·, Water .... 1·4	3·4*		Cement 1, Lime ...¼	6·7
Portland (Eng.), 320 days........	Pure cement......	10·6		Cement 1, Lime ... 1	3·9
	Cement.......... 1, Sand.............. 2	6·6	Rosendale (Hoffman), 320 days	Stiff paste...	4·4*
				Thin " ...	4·8*

* All except the first were submitted to a pressure of 32 lbs. per square inch.

Cement.	Value. Pure.	Value. Cement 1. Sand 1.	Value. Cement 1. Sand 2.	Cement.	Value. Pure.	Value. Cement 1. Sand 1.	Value. Cement 1. Sand 2.
		Lbs.	Lbs.			Lbs.	Lbs.
Akron, New York.........	5·2	4·4	4·1	Round Top, Md............	...	4·1	...
Brighton and Rosendale.	4·9	3·8	3·4	Rosendale, Hoffman........	5·8	4·1	...
Cumberland, Md...........	6·5	6·3	3·8	" Lawrence......	5·3	...	...
James River, Va............	...	4·2	4·4	Sandusky, Ohio.............	3·8	3·2	...
Newark and Rosendale..	5·8	3·8	3·4	Shepherdstown, Va........	5·1	4·2	3·1
Portland, English..........	10·5	8·6	6·5	Utica, Ill.......................	5·1	1·2	3·8
Remington, Conn..........	6·5	4·8	3·4				

Note.—When the paste is not subjected to compression during setting, a thin paste produces as strong a mortar as a stiff one.

Experiments of General Treussart.

Puzzuolana and Trass—Mortar.		Value.	Puzzuolana and Trass—Mortar.			Value.
		Lbs.				Lbs.
Strasburgh	Puzzuolana 1, Sand .... 1, Trass......... 1 — 5 days	2·8	Strasburgh..	Lime paste. 1, Puzzuolana 2½	5 days	3·8
	Lime......... 1, Sand .... 1, Puzzuolana 1 — 4 "	3·4		Lime paste. 1, Trass......... 2	8 "	3·1
			White Marble	Lime......... 1, Sand.......... 1, Trass.......... 1	5 "	2·1

Cement paste, 95 days.........	13·8	Cement paste ½, lime paste 1	4·2
" 1, lime paste ¼	13·6	Fire-brick beam †................	2·1
" 1, " ½	11·3	Portland cement, 4 mos........	21·3
" 1, " 1	7·9	Roman " 4 "	14·8

Deductions.—1. Particles of unground cement exceeding $\frac{1}{80}$ of an inch in diameter may be allowed in cement paste without sand, to the extent of 50 per cent. of the whole, without detriment to its

† Loaded partly along the bricks, and broke through them.

properties, while a corresponding proportion of sand injures the strength of mortar about 40 per cent.

2. When these unground particles exist in cement paste to the extent of 66 per cent. of the whole, the adhesive strength is diminished about 28 per cent. For a corresponding proportion of sand the diminution is 68 per cent.

3. The addition of siftings exercises a less injurious effect upon the cohesive than upon the adhesive property of cement. The converse is true when sand, instead of siftings, is used.

4. In all the mixtures with siftings, even when the latter amounted to 66 per cent. of the whole, the cohesive strength of the mortars exceeded its adhesion to the bricks. The same results appear to exist when the siftings are replaced by sand, until the volume of the latter exceeds 20 per cent. of the whole, after which the adhesion exceeds the cohesion.

5. At the age of 320 days (and perhaps considerably within that period) the cohesive strength of pure cement mortar exceeds that of Croton front bricks. The converse is true when the mortar contains 50 per cent. or more of sand.

6. When cement is to be used without sand, as may be the case when *grouting* is resorted to, or when old walls are to be repaired by injections of thin paste, there is no advantage in having it ground to an impalpable powder.

7. For economy it is customary to add lime to cement mortars, and this may be done to a considerable extent when in positions where hydraulic activity and strength are not required in an eminent degree.

Slaking.— The volume of water required to slake lime will vary with limes from 2·5 to 3 times the volume of the lime (quicklime), and it is important that all the water required to reduce the lime to a proper consistency should be given to it before the temperature of the water first given becomes sensibly elevated.

Immediately upon the lime being provided with the requisite volume of water, it should be covered, in order to confine the heat, and it should not be stirred while slaking. When the paste is required for *grouting* or *whitewashing*, the water required should be given at once, and in larger volume than when the paste is required for mortar, and when slaked the mass should be transferred to tight casks to prevent the loss of water. When the character of the limes, as with those of hydraulic energy, will not readily reduce, their reduction, which is an indispensable condition, must be aided by mechanical means, as a mortar mill.

The process here given is termed *drowning*. When the lime is retained in a barrel, or like instrument, immersed in water, and then withdrawn before reduction occurs, it is termed *immersion*, and when it is reduced by being exposed to the atmosphere, and gradually absorbing moisture therefrom, it is termed *air-slaked*.

Bricks should be well wetted before use. *Sea sand* should not be used in the composition of mortar, as it contains salt and its grains are round, being worn by attrition, and consequently having less tenacity than sharp-edged grains.

Fine Clay.— The fusibility of clay arises from the presence of impurities, such as lime, iron, and manganese. These may be removed by steeping the clay in hot muriatic acid, then washing it with water. Crucibles from common clay may be made in this manner.

Pisé is made of clay or earth rammed in layers of from 3 to 4 inches in depth. In moist climates, it is necessary to protect the external surface of a wall constructed in this manner with a coat of mortar.

Asphalt Composition.— Mineral pitch 1 part, bitumen 11, powdered stone, or wood ashes, 7 parts.

2. Ashes 2 parts, clay 3 parts, and sand 1 part, mixed with a little oil, makes a very fine and durable cement, suitable for external use.

Mastic.— Pulverized burnt clay 93 parts, litharge ground very fine 7 parts, mixed with a sufficient quantity of pure linseed oil.

3. Silicious sand 14, pulverized calcareous stone 14, litharge 2, and linseed oil 4 parts by weight.

The powders to be well dried in an oven, and the surface upon which it is to be applied must be saturated with oil.

4. *For Roads.*— Bitumen 16·875 parts, asphaltum 225 parts, oil of resin 6·25 parts, and sand 135 parts. Thickness, from $1\frac{1}{4}$ to $1\frac{5}{8}$ inches.

Asphaltum 55 lbs. and gravel 28·7 lbs. will cover an area of 10·75 square feet.

Notes by General Gillmore, U. S. A. — All the lime necessary for any required quantity or *batch* of mortar should be slaked at least one day before it is mixed with the sand.

All the water required to slake the lime should be poured on at one time, the lime should be submerged, and the mass should then be covered with a tarpaulin or canvas, and allowed to remain undisturbed for a period of 24 hours.

The ingredients should be thoroughly mixed, and then heaped for use as required.

Recent experiments have developed that most American cements will sustain, without any great loss of strength, a dose of lime paste equal to that of the cement paste, while a dose equal to $\frac{1}{2}$ to $\frac{3}{4}$ the volume of cement paste may be safely added to any Rosendale cement without producing any essential deterioration of the quality of the mortar. Neither is the hydraulic activity of the mortars so far impaired by this limited addition of lime paste as to render them unsuited for concrete under water, or other submarine masonry. By the use of lime is secured the double advantages of slow setting and economy.

Pointing Mortar is composed of a paste of finely-ground cement and clean sharp silicious sand, in such proportions that the volume of cement paste is slightly in excess of the volume of voids or spaces in the sand. The volume of sand varies from $2\frac{1}{2}$ to $2\frac{3}{4}$ that of the cement paste, or by weight, 1 of cement powder to 3 to $3\frac{1}{3}$ of sand. The mixture should be made under shelter, and in quantities not exceeding from 2 to 3 pints at a time.

Before pointing, the joints should be reamed, and in close masonry they must be open to $\frac{1}{5}$ of an inch, then thoroughly saturated with water, and maintained in a condition that they will

neither absorb water from the mortar or impart any to it. Masonry should not be allowed to dry rapidly after pointing, but it should be well driven in by the aid of a caulking iron and hammer.

In the pointing of rubble masonry the same general directions are to be observed.

Notes by General Totten, U. S. A.—240 lbs. lime = 1 cask, will make from 7·8 to 8·15 cubic feet of stiff paste.

308* lbs. of finely-ground cement will make from 3·7 to 3·8 cubic feet of stiff paste; 79 to 83 lbs. of cement powder will make 1 cubic foot of stiff paste.

1 cubic foot of dry cement powder, measured when loose, will measure ·78 to ·8 cubic foot when packed, as at a manufactory.

100 yards of lath and plaster work, with wages of masons at $1.75 per day, and Rockland lime at $1 per cask, cost, respectively: 3 Coats hard finish work, $25.50; 2 Coats slipped work, $19.95.

Mural Efflorescences.—White alkaline efflorescences upon the surface of brick walls laid in mortar, of which natural hydraulic lime or cement is the basis.

The crystallization of these salts within the pores of bricks, into which they have been absorbed from the mortar, causes disintegration.

Ashphalt Flooring.—8 lbs. of composition will cover 1 sup. foot, ¾ inch thick.

Plastering.—1 bushel, or 1¼ cubic foot of cement, mortar, etc., will cover 1½ square rods ¾ inch thick. 75 volumes are required upon brick work for 70 upon laths.

Cost of Masonry, of various Kinds, per Cubic Yard, and the Volume of Mortar required for each.

Gen. Gillmore, U. S. A.

Mortar.	Volume.	Lime, no Cement used.	Cement, no Lime used.	Difference of Cost with Cement or Lime Mortar.	Cost.	
					Lime Mortar.	Cement Mortar.
	Cu. Ft.	Bbls.	Bbls.	$ Cts.	$ Cts.	$ Cts.
Rough, in rubble or gravel, from ⅛ to ·1 cubic foot in volume	10·8	·565	1·22	90	4.10	5.
Blocks, large and small, not in courses; joints hammer-dressed	8·1	·423	·92	62	7.	7.63
Large masses; headers and stretchers dovetailed; hammer-dressed; beds and joints laid close	1·	·05	·11	08	9.	9.08
Ordinary; courses 20 to 32 in rise	1·5	·08	·17	12	5.70	
Ordinary; courses 12 to 20 in rise	2·	1·05	·22	16	2.19	
Brick	8·	·42	·9	66	5.70	6.10
Concrete, good	11·	·54	1·75	1.21	2.19	3.20
" medium	9·	·41	1·06	65	1.56	2.21
" inferior	8·	·37	·97	60	1.45	2.05
Rubble, without mortar					3. to	3.30

Cost of materials assumed as follows: Cement, $1.25 per barrel; Lime, $1; Bricks, $4.25 per M; Sand and Gravel, 80 cents per ton; Granite spalls, 55 cents per cubic yard; Labor, $1 per day.

* 300 lbs. net is the standard barrel, but it usually weighs 308 lbs.

ARTIFICERS' RULES AND TABLES,

For Computing the Work of Bricklayers, Well Diggers, Masons, Carpenters and Joiners, Slaters, Plasterers, Painters, Glaziers, Pavers, and Plumbers.

MEASUREMENT OF BRICKLAYERS' WORK.

Brickwork is estimated at the rate of a number of bricks in thickness, estimating a brick at 4 inches thick. The dimensions of a building are usually taken by measuring half round on the outside, and half round on the inside; the sum of these two gives the compass of the wall, — to be multiplied by the height, for the content of the materials. Chimneys are by some measured as if they were solid, deducting only the vacuity from the hearth to the mantle, on account of the trouble of them. And by others they are girt or measured round for their breadth, and the height of the story is their height, taking the depth of the jambs for their thickness. And in this case, no deduction is made for the vacuity from the floor to the mantle-tree, because of the gathering of the breast and wings, to make room for the hearth in the next story. To measure the chimney shafts, which appear above the building, gird them about with a line for the breadth, to multiply by their height; and account their thickness half a brick more than it really is, in consideration of the plastering and scaffolding. All windows, doors, etc., are to be deducted out of the contents of the walls in which they are placed. But this deduction is made only with regard to materials; for the whole measure is taken for workmanship, and that all outside measure too, namely, measuring quite round the outside of the building, being in consideration of the trouble of the returns or angles. There are also some other allowances, such as double measure for feathered gable ends, etc.

Example.— The end wall of a house is 28 feet long, and 37 feet high to the eaves: 15 feet high is four bricks or 16 inches thick, other 12 feet is three bricks or 12 inches thick, and the remaining 10 feet is two bricks or 8 inches thick; above which is a triangular gable 12 feet high and one brick or 4 inches in thickness. What number of bricks are there in the said wall? *Ans.* 25,620.

	Thickness.		
	$28 \times 15 = 420 \times 4 =$	1680	contents of 1st story.
	$28 \times 12 = 336 \times 3 =$	1008	" " 2d "
	$28 \times 10 = 280 \times 2 =$	560	" " 3d "
$\div 2 =$	$6 \times 28 = 168 \times 1 =$	168	" " gable.
		3416	square feet area of whole wall.
		$7\frac{1}{2}$	bricks to square foot.
		23,912	By the table.
		1,708	3000 suprfi. ft. = 22,500 bricks
			400 " " = 3,000 "
Answer,		25,620 bricks.	10 " " = 75 "
			6 " " = 45 "
			3416 " " = 25,620 bricks

A Table by which to ascertain the Number of Bricks necessary to Construct any piece of Building, from a four-inch Wall to twenty-four inches in thickness.

The utility of the Table can be seen by the following Example. Required the number of bricks to build a wall of 12 inches thickness, and containing an area of 6,437 square feet.

Square feet 1000	22,500 bricks — See table.	
× 6	6	
6000 =	135,000	NOTE.—$7\frac{1}{2}$ bricks, equal one superficial foot.
400 =	9,000	
30 =	675	
7 =	158	
6,437 =	144,833 bricks.	

Superficial feet of Wall	Number of Bricks to Thickness of					
	4-inch.	8-inch.	12-inch.	16-inch.	20-inch.	24-inch.
1	8	15	23	30	38	45
2	15	30	45	60	75	90
3	23	45	68	90	113	135
4	30	60	90	120	150	180
5	38	75	113	150	188	225
6	45	90	135	180	225	270
7	53	105	158	210	263	315
8	60	120	180	240	300	360
9	68	135	203	270	338	405
10	75	150	225	300	375	450
20	150	300	450	600	750	900
30	225	450	675	900	1125	1350
40	300	600	900	1200	1500	1800
50	375	750	1125	1500	1875	2250
60	450	900	1350	1800	2250	2700
70	525	1050	1575	2100	2625	3150
80	600	1200	1800	2400	3000	3600
90	675	1350	2025	2700	3375	4050
100	750	1500	2250	3000	3750	4500
200	1500	3000	4500	6000	7500	9000
300	2250	4500	6750	9000	11250	13500
400	3000	6000	9000	12000	15000	18000
500	3750	7500	11250	15000	18750	22500
600	4500	9000	13500	18000	22500	27000
700	5250	10500	15750	21000	26250	31500
800	6000	12000	18000	24000	30000	36000
900	6750	13500	20250	27000	33750	40500
1000	7500	15000	22500	30000	37500	45000

MEASUREMENT OF WELLS AND CISTERNS.

There are two methods of estimating the value of excavating. It may be done by allowing so much a day for every man's work, or so much per cubic foot, or yard, for all that is excavated.

Well Digging.— Suppose a well is 40 feet deep, and 5 feet in diameter, required the number of cubic feet, or yards?

$$5 \times 5 = 25 \times \cdot 7851 = 19 \cdot 635 \times 40 = 785 \cdot 4 \text{ cubic feet.}$$

Suppose a well to be 4 feet 9 inches diameter, and 16½ feet from the bottom to the surface of the water; how many gallons are therein contained?

$$4 \cdot 75^2 \times 16 \cdot 5 \times 5 \cdot 875 = 2187 \cdot 152 \text{ gallons.}$$

Again, suppose the well's diameter the same, and its entire depth 35 feet; required the quantity in cubic yards of material excavated in its formation.

$$4 \cdot 75^2 \times 35 \times \cdot 02909 = 22 \cdot 972 \text{ cubic yards.}$$

A cylindrical piece of lead is required 7½ inches diameter, and 168 lbs. in weight; what must be its length in inches?

$$7 \cdot 5^2 \times \cdot 3223 = 18, \text{ and } 168 \div 18 = 9 \cdot 3 \text{ inches.}$$

Digging for Foundations, etc.— To find the cubical quantity in a trench, or an excavated area, the length, width and depth must be multiplied together. These are usually given in feet, and therefore, to reduce the amount into cubic yards it must be divided by 27.

Suppose a trench is 40 feet long, 3 feet wide, and 3 feet deep, required the number of cubic feet, or yards?

$$40 \times 3 = 120 \times 3 = 360 \text{ feet} \div 27 = 13\tfrac{1}{3} \text{ yards.}$$

24 cubic feet of sand, 17 ditto clay, 18 ditto earth, equal one ton.

1 cubic yard of earth or gravel, before digging, will occupy about 1½ cubic yards when dug.

MEASUREMENT OF MASONS' WORK.

To masonry belongs all sorts of stone-work; and the measure made use of is a foot, either superficial or solid.

Walls, columns, blocks of stone or marble, etc., are measured by the cubic foot; and pavements, slabs, chimney-pieces, etc., by the superficial or square foot. Cubic or solid measure is used for the materials, and square measure for the workmanship. In the solid measure, the true length, breadth and thickness are taken, and multiplied continually together. In the superficial, there must be taken the length and breadth of every part of the projection, which is seen without the general upright face of the building.

EXAMPLE.— In a chimney-piece, suppose the length of the mantle and slab each 4 feet 6 inches; breadth of both together 3 feet

2 inches; length of each jamb 4 feet 4 inches; breadth of both together 1 foot 9 inches. Required the superficial content.— *Ans.* 21 feet 10 inches.

$$\left.\begin{array}{l} 4\text{ ft. }6\text{ in.}\times 3\text{ ft. }2\text{ in.} = 14\text{ ft. }3\text{ in.} \\ 4\text{ ``}\ 4\text{ ``}\times 1\text{ ``}\ 9\text{ ``} = \ 7\text{ ``}\ 7\text{ ``} \end{array}\right\}21\text{ feet }10\text{ inches.}$$

Rubble Walls (unhewn stone) are commonly measured by the perch, which is $16\frac{1}{2}$ feet long, 1 foot deep, and $1\frac{1}{2}$ foot thick, equivalent to $24\frac{3}{4}$ cubic feet. 25 cubic feet is sometimes allowed to the perch, in measuring stone before it is laid, and 22 after it is laid in the wall. This species of work is of two kinds, coursed and uncoursed; in the former the stones are gauged and dressed by the hammer, and the masonry laid in horizontal courses, but not necessarily confined to the same height. The uncoursed rubble wall is formed by laying the stones in the wall as they come to hand, without any previous gauging or working.

27 cubic feet of **Mortar** require for its preparation 9 bushels of lime and 1 cubic foot of sand.

Lime and sand lessen about one-third in bulk when made into mortar; likewise cement and sand.

Lime, or cement and sand, to make *mortar*, require as much water as is equal to one-third of their bulk.

All **Sandstones** ought to be placed on their natural beds; from inattention to this circumstance, the stones often split off at the joints, and the position of the lamina much sooner admits of the destructive action of air and water.

The heaviest stones are most suited for docks and harbors, breakwaters to bridges, etc.

Granite is the most durable species of stone yet known for the purposes of building. It varies in weight according to quality; the heaviest is the most durable.

MEASUREMENT OF CARPENTERS' AND JOINERS' WORK.

To this branch belongs all the woodwork of a house, such as flooring, partitioning, roofing, etc. Large and plain articles are usually measured by the square foot or yard, etc., but enriched mouldings, and some other articles, are often estimated by running or lineal measures, and some things are rated by the piece.

All **Joints, Girders**, and in fact all the parts of naked flooring, are measured by the cube, and their quantities are found by multiplying the length by the breadth, and the product by the depth. The same rule applies to the measurement of all the timbers of a roof, and also the framed timbers used in the construction of partitions.

Flooring, that is to say, the boards which cover the naked flooring, is measured by the square. The dimensions are taken from wall to wall, and the product is divided by 100, which gives the

number of squares; but deductions must be made for staircases and chimneys.

In measuring of **Joists**, it is to be observed that only one of their dimensions is the same with that of the floor; for the other exceeds the length of the room by the thickness of the wall, and one-third of the same, because each end is let into the wall about two-thirds of its thickness.

No deductions are made for **Hearths** on account of the additional trouble and waste of materials.

Partitions are measured from wall to wall for one dimension, and from floor to floor, as far as they extend, for the other.

No deduction is made for **Doorways** on account of the trouble of framing them.

In measuring of **Joiners' work**, the string is made to ply close to every part of the work over which it passes.

The measure for centring for **Cellars** is found by making a string pass over the surface of the arch for the breadth, and taking the length of the cellar for the length; but in groin centring, it is usual to allow double measure, on account of their extraordinary trouble.

In **Roofing**, the length of the house in the inside, together with two-thirds of the thickness of one gable, is to be considered as the length; and the breadth is equal to double the length of a string which is stretched from the ridge down the rafter, and along the eaves-board, till it meets with the top of the wall.

For **Staircases**, take the breadth of all the steps, by making a line ply close over them, from the top to the bottom, and multiply the length of this line by the length of a step, for the whole area.—By the length of a step is meant the length of the front and the returns at the two ends; and by the breadth, is to be understood the girth of its two outer surfaces, or the tread and riser.

For the **Balustrade**, take the whole length of the upper part of the handrail, and girt over its end till it meets the top of the newel post, for the length; and twice the length of the baluster upon the landing, with the girth of the handrail for the breadth.

For **Wainscoting**, take the compass of the room for the length; and the height from the floor to the ceiling, making the string ply close into all the mouldings, for the breadth. Out of this must be made deductions for windows, doors, chimneys, etc., but workmanship is counted for the whole, on account of the extraordinary trouble.

For **Doors**, it is usual to allow for their thickness, by adding it to both dimensions of length and breadth, and then to multiply them together for the area. If the door be panelled on both sides, take double its measure for the workmanship; but if the one side only be panelled, take the area and its half for the workmanship. For the *surrounding architrave*, gird it about the outermost parts for its length; and measure over it, as far as it can be seen when the door is open, for the breadth.

Window-shutters, bases, etc., are measured in the same manner.

In the measuring of **Roofing** for workmanship alone, holes for chimney-shafts and sky-lights are generally deducted. But in measuring for work and materials, they commonly measure in all sky-lights, lutheran-lights, and holes for the chimney-shafts, on account of their trouble and waste of materials.

The **Doors and Shutters**, being worked on both sides, are reckoned work and half work.

Hemlock and Pine Shingles are generally 18 inches long, and of the average width of 4 inches. When nailed to the roof 6 inches are generally left out to the weather, and 6 shingles are therefore required to a square foot. *Cedar* and *Cypress* Shingles are generally 20 inches long and 6 inches wide, and therefore a less number are required for a "square." On account of waste and defects, 1000 shingles should be allowed to a square.

Two 4-penny **Nails** are allowed to each shingle, equal to 1200 to a square.

The weight of a square of **Partitioning** may be estimated at from 1500 to 2000 lbs.; a square of single-joisted flooring, at from 1200 to 2000 lbs.; a square of framed flooring, at from 2700 to 4500 lbs.; a square of deafening, at about 1500 lbs. 100 superficial feet make one square of boarding, flooring, etc.

In selecting **Timber**, avoid spongy heart, porous grain, and dead knots; choose the brightest in color, and where the strong red grain appears to rise on the surface.

Number of American Iron Machine-Cut Nails in a Pound (by count).

Size.	Number.	Size.	Number.	Size.	Number.
3 penny	408	6 penny	156	12 penny	52
4 "	275	8 "	100	20 "	32
5 "	227	10 "	66	30 "	25

MEASUREMENT OF SLATERS' WORK.

In these articles, the content of a roof is found by multiplying the length of the ridge by the girth over from eaves to eaves; making allowance in this girth for the double row of slates at the bottom, or for how much one row of slates is laid over another. When the roof is of a true pitch, that is, forming a right angle at top, then the breadth of the building, with its half added, is the girth over both sides. In angles formed in a roof, running from the ridge to the eaves, when the angle bends inwards, it is called a valley; but when outwards, it is called a hip. It is not usual to make deductions for chimney-shafts, sky-lights or other openings.

Slates,

[*From the Quarries of Rutland County, Vermont.*]

3 Inch Cover.		2 Inch Cover.	3 Inch Cover.		2 Inch Cover.
Sizes of Slates.	No. of Slates to the Square or 100 Feet.	No. of Slates to the Square or 100 Feet.	Sizes of Slates.	No. of Slates to the Square or 100 Feet.	No. of Slates to the Square or 100 Feet.
24 by 16	86	84	18 by 11	174¼	163½
24 by 14	98	93½	18 by 10	192	180
24 by 12	114	109	18 by 9	213	200
22 by 14	108	102¼	16 by 12	184	171½
22 by 12	126	120	16 by 10	221½	205¾
22 by 10	152	144	16 by 9	246	228½
20 by 14	129	114¼	16 by 8	277	257
20 by 12	143	133⅓	14 by 10	262	240
20 by 11	146	145½	14 by 9	293	266½
20 by 10	169¼	160	14 by 8	327	300
18 by 12	160	150	14 by 7	374	343

"Each Slate is 3 inches BOND OR COVER. The rule for measuring Slating is, to add one foot for all hips and valleys. No deduction is made for Lutheran windows, sky-lights or chimneys, except they are of unusual size; then one-half is deducted."

Imported Slates.

Names of Slates.	Sizes.	Number of Superficial Feet each M of 1200 will cover.	Weight of each M of 1200 Slates.
	Inches. Inches.		
Duchesses	24 by 12	1100	60 cwt.
Marchionesses	22 " 12	1000	55 "
Countesses	20 " 10	750	40 "
Viscountesses	18 " 10	666⅔	36 "
Ladies	16 " 10	583⅓	31 "
"	16 " 8	466⅔	25 "
"	14 " 8	400	22 "
"	12 " 8	333⅓	18½ "
Plantations	14 " 12	600	33 "
"	13 " 10	458⅓	25 "
"	12 " 10	416⅔	23 "
Doubles	13 " 7	320⅚	17½ "
" small	11 " 7	262½	14½ "
School Slates for Blackboards	5 ft. by 2½ ft. 5 feet by 3 ft.		

MEASUREMENT OF PLASTERERS' WORK.

Plasterers' work is of two kinds, namely, ceiling — which is plastering upon laths — and rendering, which is plastering upon walls, which are measured separately.

The contents are estimated either by the foot or yard, or square of 100 feet. Enriched mouldings, etc., are rated by running or lineal measure. One foot extra is allowed for each mitre.

One-half of the openings, windows, doors, etc., allowed to compensate for trouble of finishing returns at top and sides.

Cornices and mouldings, if 12 inches or more in girt, are sometimes estimated by the square foot; if less than 12 inches, they are usually measured by the lineal foot.

1 bushel of cement will cover $1\frac{1}{7}$ square yards at 1 inch in thickness.

1 bushel of cement will cover $1\frac{1}{2}$ square yards at $\frac{3}{4}$ths of an inch in thickness.

1 bushel of cement will cover $2\frac{1}{4}$ square yards at $\frac{1}{2}$ of an inch in thickness.

1 bushel of cement and 1 of sand will cover $2\frac{1}{4}$ square yards at 1 inch in thickness.

1 bushel of cement and 1 of sand will cover 3 square yards at $\frac{3}{4}$ths of an inch in thickness.

1 bushel of cement and 1 of sand will cover $4\frac{1}{2}$ square yards at $\frac{1}{2}$ of an inch in thickness.

1 bushel of cement and 2 of sand will cover $3\frac{1}{3}$ square yards at 1 inch in thickness.

1 bushel of cement and 2 of sand will cover $4\frac{1}{2}$ square yards at $\frac{3}{4}$ths of an inch in thickness.

1 bushel of cement and 2 of sand will cover $6\frac{3}{4}$ square yards at $\frac{1}{2}$ of an inch in thickness.

1 cwt. of mastic and 1 gallon of oil will cover $1\frac{1}{2}$ yards at $\frac{3}{4}$, or $2\frac{1}{2}$ at $\frac{1}{2}$ inch.

1 cubic yard of lime, 2 yards of road or drift sand, and 3 bushels of hair, will cover 75 yards of *render and set* on brick, and 70 yards on lath, or 65 yards *plaster*, or *render*, *2 coats and set* on brick, and 60 yards on lath; floated work will require about the same as 2 coats and set.

Laths are $1\frac{1}{4}$ to $1\frac{1}{2}$ inches by 4 feet in length, and are usually set $\frac{1}{4}$th of an inch apart. A bundle contains 100. 1 bundle of laths and 500 nails cover about $4\frac{1}{2}$ yards.

MEASUREMENT OF PAVERS' WORK.

Pavers' work is done by the square yard; and the content is found by multiplying the length by the breadth. Grading for paving is charged by the day.

MEASUREMENT OF GLAZIERS' WORK.

Glaziers' work is sometimes measured by the square foot, sometimes by the piece, or at so much per light; except where the glass is set in metallic frames, when the charge is by the foot. In estimating by the square foot, it is customary to include the whole sash. Circular or oval windows are measured as if they were square.

Table showing the Size and Number of Lights to the 100 Square Feet.

Size.	Lights.	Size.	Lights.	Size.	Lights.	Size.	Lights.
6 by 8	300	12 by 14	86	14 by 22	47	20 by 20	36
7 by 9	229	12 by 15	80	14 by 24	43	20 by 22	33
8 by 10	180	12 by 16	75	15 by 15	64	20 by 24	30
8 by 11	164	12 by 17	71	15 by 16	60	20 by 25	29
8 by 12	150	12 by 18	67	15 by 18	53	20 by 26	28
9 by 10	160	12 by 19	63	15 by 20	48	20 by 28	26
9 by 11	146	12 by 20	60	15 by 21	46	21 by 27	25
9 by 12	133	12 by 21	57	15 by 22	44	22 by 24	27
9 by 13	123	12 by 22	55	15 by 24	40	22 by 26	25
9 by 14	114	12 by 23	52	16 by 16	56	22 by 28	23
9 by 16	100	12 by 24	50	16 by 17	53	24 by 28	21
10 by 10	144	13 by 14	79	16 by 18	50	24 by 30	20
10 by 12	120	13 by 15	74	16 by 20	45	24 by 32	19
10 by 13	111	13 by 16	69	16 by 21	43	25 by 30	19
10 by 14	103	13 by 17	65	16 by 22	41	26 by 36	15
10 by 15	96	13 by 18	61	16 by 24	38	28 by 34	15
10 by 16	90	13 by 19	58	17 by 17	50	30 by 40	12
10 by 17	85	13 by 20	55	17 by 18	47	31 by 36	13
10 by 18	80	13 by 21	53	17 by 20	42	31 by 40	12
11 by 11	119	13 by 22	50	17 by 22	38	31 by 42	12
11 by 12	109	13 by 24	46	17 by 24	35	32 by 42	10
11 by 13	101	14 by 14	73	18 by 18	44	32 by 44	10
11 by 14	94	14 by 15	68	18 by 20	40	33 by 45	10
11 by 15	87	14 by 16	64	18 by 22	36	34 by 46	9
11 by 16	82	14 by 17	60	18 by 24	33	30 by 52	9
11 by 17	77	14 by 18	57	19 by 19	40	32 by 56	8
11 by 18	73	14 by 19	54	19 by 20	38	33 by 56	8
12 by 12	100	14 by 20	51	19 by 22	34	36 by 58	7
12 by 13	92	14 by 21	49	19 by 24	32	38 by 58	7

MEASUREMENT OF PAINTERS' WORK.

Painters' work is computed in square yards. Every part is measured where the color lies; the measuring line is forced into all the mouldings and corners.

Cornices, mouldings, narrow skirtings, reveals to doors and windows, and generally all work not more than nine inches wide, are valued by their length. Sash-frames are charged so much each according to their size, and the squares so much a dozen. Mouldings cut in are charged by the foot run, and the workman always receives an extra price for party-colors. Writing is charged by the inch, and the price given is regulated by the skill and manner in which the work is executed; the same is true of imitations and marbling. The price of painting varies exceedingly, some colors being more expensive and requiring much more labor than others. In measuring open railing, it is customary to take it as flat work, which pays for the extra labor; and as the rails are painted on all sides, the two surfaces are taken. It is customary to allow all edges and sinkings.

MEASUREMENT OF PLUMBERS' WORK.

Plumbers' work is rated at so much a pound, or else by the hundredweight of 112 pounds. Sheet lead, used in roofing, guttering, etc., is from 7 to 12 pounds to the square foot. And a pipe of an inch bore is commonly from 6 to 13 pounds to the yard in length.—[See Table, "*Weight of Lead Pipe per Foot.*"]

SEWERS.

Sewers are classed as Drains, Sewers, and Culverts.

Drains are the small courses, as from one or more locations leading to a sewer.

Sewers are the courses from a series of locations.

Culverts are the courses that receive the discharge of sewers.

The greatest fall of rain is 2 inches per hour = 54308·6 gallons per acre.

Drainage of Lands by Pipes.

Soils.	Depth of Pipes.		Distance apart.	Soils.	Depth of Pipes.		Distance apart.
	Ft.	In.	Feet.		Ft.	In.	Feet.
Coarse gravel sand......	4	6	60	Loam with gravel...	3	3	27
Light sand with gravel	4		50	Sandy loam............	3	9	40
Light loam..................	3	6	33	Soft clay..................	2	9	21
Loam with clay..........	3	2	21	Stiff clay................	2	6	15

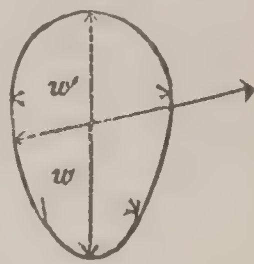
Sewers.

Circular. $55\sqrt{x \times 2f} = v$, and $v \times a = V$; *x representing area of sewer ÷ the wetted perimeter, f inclination of do. per mile, and v velocity of flow, in feet per minute; a area of flow in square feet, and* V *volume of discharge in cubic feet per minute.*

Egg. $\frac{D}{3} = w$, $\frac{2D}{3} = w'$, and $D = r$. D *representing height of sewer, w and w′ width at bottom and top, and r radius of sides.*

In culverts less than 6 feet in depth,* the brick-work should be 9 inches thick. When they are above 6 feet and less than 9 feet, it should be 14 inches thick.

Fig. 42.



If the diameter of top arch = 1, the diameter of inverted arch = ·5, and the total depth = the sum of the two diameters, or 1·5, then the radius of the arcs which are tangential to the top, and inverted, will be 1·5.

From this any two of the elements can be deduced, one being known.

Oval. Top and bottom* should be of equal diameters. The diameter ·76 depth of culvert; the intersections of the top and bottom circles form the centres for striking the courses connecting the top and bottom circles.

The inclination of sewers should not be less than 1 foot in 240.

Dimensions, Areas, and Volume of Work per Lineal Foot of Egg-shaped Sewers of different Dimensions.

Internal Dimensions.				Volume of Brick-work.		
Depth.	Diameter of Top Arch.	Diameter of Invert.	Area.	4½ Inch Thick.	9 Inch Thick.	13½ Inch Thick.
Feet.	Feet.	Feet.	Sq. Feet.	Cub. Feet.	Cub. Feet.	Cub. Feet.
2·¼	1·5	·75	2·53	2·81	......	......
3·	2·	1·	4·5	3·56	......	......
3·¾	2·5	1·25	7·03	4·31	9·56	......
4·½	3·	1·5	10·12	5·06	10·87	......
5·½	3·5	1·75	13·78	5·81	12·75	......
6·	4·	2·	18·	6·56	14·25	......
6·¾	4·5	2·25	22·78	7·31	15·75	24·75
7·½	5·	2·5	28·12	......	17·06	27·
8·¼	5·5	2·75	34·03	......	18·	28·41
9·	6·	3·	40·5	......	19·69	30·94

In laying large sewers through quicksands, cast-iron inverts are sometimes employed, and with success, to connect the foundation of the whole work together.

* Internal dimensions.

Area of Surface from which Circular Sewers will discharge Water equal in Volume to One Inch in Depth upon surface per Hour, including ordinary City Drainage.

Inclination in Feet.	Diameter of Sewers in Feet.					
	2	2½	3	4	5	6
	Area.	Area.	Area.	Area.	Area.	Area.
None	38¾	67¼	120	277	570	1020
1 in 480......	48	75	135	308	630	1117
1 in 240......	50	87	155	355	735	1318
1 in 160......	63	113	203	460	950	1692
1 in 120......	78	143	257	590	1200	2180
1 in 80.......	90	165	295	570	1388	2486
1 in 60.......	125	182	318	730	1500	2675

ARCHES AND ABUTMENTS.

Approximate Rules and Tables for the Depth of Arches and Thickness of Abutments.

$C\sqrt{r} = D$. C *representing coefficient*, *r radius of arch at crown*, *t thickness of abutment*, *h height of abutment to spring*, *and* D *depth of crown in feet.*

In single arches, Stone C = ·3, Brick ·4, and Rubble ·45.

Depths required for the Crowns of Arches.

Radius of Curve.	Ston'	Brick.	Radius of Curve.	Stone.	Brick.	Radius of Curve.	Stone.	Brick.	Radius of Curve.	Stone.	Brick.
Feet.	Feet	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
2	·42	·56	10	·95	1·26	24	1·47	1·96	80	2·68	3·58
2½	·47	·63	11	1·	1·33	25	1·5	2·	85	2·77	3·69
3	·52	·69	12	1·04	1·38	30	1·64	2·19	90	2·85	3·8
3½	·56	·75	13	1·08	1·44	35	1·78	2·37	95	2·92	3·9
4	·6	·8	14	1·12	1·5	40	1·9	2·53	100	3·	4·
4½	·64	·85	15	1·16	1·55	45	2·01	2·68	110	3·15	4·2
5	·67	·9	16	1·2	1·6	50	2·12	2·83	120	3·29	4·38
5½	·71	·94	17	1·23	1·65	55	2·22	2·97	130	3·42	4·56
6	·74	·98	18	1·27	1·7	60	2·33	3·1	140	3·55	4·73
7	·8	1·06	19	1·31	1·74	65	2·42	3·22	150	3·67	4·9
8	·85	1·13	20	1·34	1·79	70	2·51	3·35	160	3·8	5·06
9	·9	1·2	22	1·41	1·88	75	2·6	3·46	170	4·13	5·22

Minimum Thickness of Abutments for Arches of 120°, where their Depth does not exceed 3 Feet.

Computed from the formula —

$$\sqrt{6r + \left(\frac{3r}{2h}\right)^2} - \frac{3r}{2h} = t.$$

Radius of Arch.	Height of Abutment to Spring in Feet.					Radius of Arch.	Height of Abutment to Spring in Feet.				
	5	7·5	10	20	30		5	7·5	10	20	30
Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
4·	3·7	4·2	4·3	4·6	4·7	12·	5·6	6·4	6·9	7·6	7·9
4·5	3·9	4·4	4·6	4·9	5·	15·	6·	7·	7·5	8·4	8·8
5·	4·2	4·9	4·8	5·1	5·2	20·	6·5	7·7	8·4	9·6	10·
6·	4·5	4·7	5·2	5·6	5·7	25·	6·9	8·2	9·1	10·5	11·1
7·	4·7	5·2	5·5	6·	6·1	30·	7·2	9·7	9·7	11·1	12·
8·	4·9	5·5	5·8	6·4	6·5	35·	7·4	9·1	10·2	11·8	12·9
9·	5·1	5·8	6·1	6·7	6·9	40·	7·6	9·4	10·6	12·8	13·6
10·	5·3	6·	6·4	7·1	7·3	45·	7·8	9·7	11·	13·4	14·3
11·	5·5	6·2	6·6	7·3	7·6	50·	7·9	10·	11·4	14·	15·

NOTE.— The abutments are assumed to be without counterforts or wing walls.

Keystones.

To Compute the Depth of Keystones for Segmental Arches of Stone.
(TRAUTWINE.)

First Class of Arch. ·36 $\sqrt{}$ of the radius at the crown.
Second Class of Arch. ·4 $\sqrt{}$ of the radius at the crown.
Brick or Rubble. ·45 $\sqrt{}$ of the radius at the crown.
In *Viaducts* of several Arches. Increase the above units to ·42, ·46, and·51.

Railway Bridges.

For Spans between 25 and 70 feet.
Rise, $\frac{1}{5}$ of the Span. *Depth of Arch*, ·055 of the Span.
Thickness of Abutments, from $\frac{1}{4}$ to $\frac{1}{5}$ of the Span. *Batter*, 1 inch per foot.

Cost of Tunnels.—(*General G. B. McClellan, U. S. A.*)

Location.	Per Cubic Yard.	Location.	Per Cubic Yard.
	\$ Cts.		\$ Cts.
Black Rock, U. S., greywacke slate	6 60	England, freestone, marble, clay, etc., lined	3 46
Blaisley, France, lined	3 18	Lehigh, U. S., hard granite	4 36
Blisworth, Eng., blue clay, lined	1 55	Schuylkill, U. S., slate	2 00
Blue Ridge, U. S.	4 00	Union, U. S., slate	2 08

Railway Tunnels.

In soft sandstone, U. S., without lining, per lineal yard...	$88 00
In loose ground, thick lining, per lineal yard................	710 00
Ordinary brick lining, including centring, per cubic yard.	8 50

Shafts.

Blaisley Tunnel, clay, chalk, and loose earth, per yard in depth, $139.11. Deepest, 646 feet.

Black Rock, 7 feet in diameter and 139 in depth, hard slate, per yard in depth, $79.50, or per cubic yard, $18.72.

The time required to drive the heading of the Black Rock Tunnel for 1782·5 feet was 2387 turns of 12 hours each.

IRON WORKS (ENGLAND).

Temperature of hot blast.. 600°

Density of blast and of refining furnace.... $2\frac{1}{2}$ to 3 lbs. per sq. in.

Revolutions of puddling rolls per minute, 60; rail rolls, 100; rail saw, 800.

Horse-power (indicated) required for different Processes.

Blast furnace....................	60	Rail rolling train.............	250
Refining furnace................	26	Small bar train................	60
Puddling rolls with squeezers and shears.....................	80	Double rail saw................	12
		Straightening	7

Rolling-Mills.

10 tons bar iron per day......	80	Plates, for each sq. ft. rolled.	5

FLOUR MILLS, SAW MILLS, WOOD-WORKING MACHINERY.

Flour Mills.

For each pair of 4-feet stones, with all the necessary dressing machinery, etc., there is required 15 horses' power.

One pair of 4-feet stones will grind about 5 bushels of wheat per hour. Each bushel of wheat so ground per hour requires ·87 actual or 1·11 indicated horses' power, exclusive of dressing and other machinery.

Stones, 4 feet diameter. 120 to 140 revolutions per minute.

Dressing Machines, 21 inches diameter, 450 to 500 revolutions per minute.

Creepers, $3\frac{1}{2}$ inches pitch, 75 revolutions per minute.

Elevator, 18 inches diameter, 40 revolutions per minute.

Screen, 16 inches diameter, 300 to 350 revolutions per minute.

788 cubic feet of water, discharged at a velocity of 1 foot per second, are necessary to grind and dress 1 bushel of wheat per hour $\doteq$ 1·49 horses' power per bushel.

2000 feet per minute, for the velocity of a stone 4 feet in diameter, may be considered a maximum speed.

Saw-Mills.

Gang saw, 30 square feet of dry oak, or 45 square feet of dry pine, per hour	1 horse-power.
Circular saw, 2·5 feet in diameter, 270 revolutions per minute, 40 square feet of oak, or 70 of dry spruce...	1 "

300 revolutions per minute. 1·33 square feet of dry pine per minute, kerf $\frac{7}{32}$ inch and 6 inches deep, requires the power of 1 horse for the saw alone; and 1 square foot, kerf $\frac{1}{4}$ inch and 1 foot in depth, requires a like power.

4·5 feet in diameter, kerf $\frac{1}{4}$ and 1 foot in depth, requires 1 horse's power for 1·33 feet per minute.

Oak requires nearly one-half more power than pine.

With a kerf of $\frac{1}{8}$ inch, 1 horse's power will saw 2·66 square feet per minute.

The speed of the periphery should be about 50 feet per minute.

Velocities of Wood-working Machinery in Feet or Revolutions per Minute.

Circular saws, at periphery, 6000 to 7000 feet.

Band saw, 2500 feet.

Gang saws, 20 inch stroke, 120 strokes per minute.

Scroll saws, 300 strokes per minute.

Planing-machine cutters at periphery, 4000 to 6000 feet.

Work under planing-machine, $\frac{1}{20}$th of an inch for each cut.

Moulding-machine cutters, 3500 to 4000 feet.

Squaring-up-machine cutters, 7000 to 8000 feet.

Wood-carving drills, 5000 revolutions.

Machine augers, $1\frac{1}{2}$ diameter, 900 revolutions.

Machine augers, $\frac{3}{4}$ diameter, 1200 revolutions.

Gang saws require for 45 superficial feet of pine per hour, 1 horse power.

Circular saws require for 75 superficial feet of pine per hour, 1 horse power.

In oak or hard wood, $\frac{3}{4}$ths of the above quantity require 1 horse power.

Sharpening Angles of Machine Cutters.

Adzing soft wood across the grain	30°	Gouges and ploughing machines	40°
Planing-machines, ordinary soft wood	35°	Hard-wood tool cutters	50° to 55°

MINING AND BLASTING.

Mining.

In ordinary Soil, $\frac{l^3}{10}$ = *charge of powder in pounds, l representing half the depth of the line of least resistance.*

In Masonry, $l^3 \times C$ = *charge in pounds; C representing a coefficient depending upon the structure.*

In a plain Wall, C = ·15, in one with counterforts = ·2, and under a foundation when it is supported upon two sides = ·4 to ·6.

Blasting.

In small blasts, 1 pound of powder will loosen about $4\frac{1}{2}$ tons.

In large blasts, 1 pound of powder will loosen about $2\frac{3}{4}$ tons.

50 or 60 pounds of powder, enclosed in a resisting bag, hung or propped up against a gate or barrier, will demolish any ordinary construction.

One man can bore, with a bit 1 inch in diameter, from 50 to 100 inches per day of 10 hours in granite, or 300 to 400 inches per day in limestone.

Two strikers and a holder can bore, with a bit 2 inches in diameter, 10 feet in a day in rock of medium hardness.

PROJECTION OF WATER.

Heights to which Water may be Projected through Engine Pipes under Pressure.

Pressure per Sq. Inch.	Equivalent Head of Water.	Height of Jet.	Ratio of Compression of Air in Air-chamber.	Pressure per Sq. Inch.	Equivalent Head of Water.	Height of Jet.	Ratio of Compression of Air in Air-chamber.
Lbs.	Feet.	Feet.		Lbs.	Feet.	Feet.	
30	68	33	·5	90	204	165	·17
45	102	66	·33	105	238	198	·14
60	136	99	·25	120	272	231	·125
75	170	132	·2	150	340	297	·1

Power required to raise Water from Wells by a Double-acting Lifting Pump.

Diameter of Pump.	Volume per Hour.	Depth from which this Volume can be raised by each Unit of Power.			
		Man turning a Crank.	Donkey working a Gin.	Horse working a Gin.	One Horse-power Engine.
Inches.	Gallons.	Feet.	Feet.	Feet.	Feet.
2	265	80	160	560	880
$2\frac{1}{2}$	420	50	100	350	550
3	620	35	70	245	385
$3\frac{1}{2}$	830	25	50	175	275
4	1060	20	40	140	220

[See page 159.]

WATER-POWER.

To Compute Water-power.

$\cdot 00189\ V\,h =$ *horse's power, and* $\frac{528\ HP}{V} = V$; V *representing volume of water, in cubic feet, per minute, and h head of water from race in feet.*

Effective Horse-power for different Motors.

Theoretical power .... 1·

Undershot wheels......... =	·4	Reaction wheel........... =	·2
Poncelet's un'shot wheel =	·6	Impact wheel .... =	·5
Breast wheel (high)...... =	·55	Turbines..................... =	{ ·6, ·75
" (low)....... =	·6		
Overshot wheel........... =	{ ·84, ·64	Tremont turbine.......... =	·79
		Hydraulic ram .... =	·6

Hydraulic Ram.

$\frac{882\ HP}{h} = V$, $\cdot 00113\ V\,h = HP$; V *representing volume of water in cubic feet per minute, h head of water in feet, and* HP *actual horse-power.*

Jet Pump.

The greatest effect of a Jet Pump is when the depth from which the water is drawn through the supply or suction pipe is ·9 of the height from which the water fell to give the jet.

The flow up the suction pipe being ·2 of that of the volume of the jet; hence the effect $= \cdot 9 \times 2 = \cdot 18$.

Imperial Gallons.

6·2355 Gallons in a Cubic Foot.

WAVES.

The undulations of waves are performed in the same time as the oscillations of a pendulum, the length of which is equal to the breadth of a wave, or to the distance between two neighboring cavities or eminences.

SOLDERS.

	Copper.	Tin.	Lead.	Zinc.	Silver.	Bismuth.	Gold.	Calcimine	Antimony
Tin	......	25	75	......	......	......	......	......	......
"	......	58	16	......	......	16	......	......	10
" coarse, melts at 500°	......	33	67	......	......	......	......	......	......
" ordinary, melts at 360°	......	67	33	......	......	......	......	......	......
Spelter, soft	50	......	......	50	......	......	......	......	......
" hard	67	......	......	33	......	......	......	......	......
Lead	......	33	67	......	......	......	......	......	......
Steel	13	......	......	5	82	......	......	......	......
Brass or Copper	50	......	......	50	......	......	......	......	......
Fine Brass	47	......	......	47	6	......	......	......	......
Pewterers' or Soft	......	33	45	......	......	22	......	....	......
" "	......	50	25	......	......	25	......	......	......
Gold	4	......	......	......	7	......	89	......	......
" hard	66	......	......	34	......	......	......	......	......
" soft	......	66	34	.. ...	......	......	......	......	......
Silver, hard	20	......	......	......	80	......	......	......	......
" soft	12	......	......	......	67	......	......	21	......
Pewter	......	40	20	......	......	40	......	......	......
Iron	66	......	......	33	......	......	......	......	1
Copper	53	47	......	......	......	......	......	......	......

A Plastic Metallic Alloy.—See Journal of Franklin Institute, vol. xxxix, page 55, for its composition and manufacture.

Composition for Welding Cast Steel.—Borax, 10 parts; sal-ammoniac, 1 part. Grind or pound them roughly together; fuse them in a metal pot over a clear fire, continuing the heat until all spume has disappeared from the surface. When the liquid is clear, pour the composition out to cool and concrete, and grind to a fine powder; then it is ready for use.

To use this composition, the steel to be welded should be raised to a bright yellow heat; then dip it in the welding powder, and again raise it to a like heat as before; it is then ready to be submitted to the hammer.

FUSIBLE COMPOUNDS.

Compounds.	Zinc.	Tin.	Lead.	Bismuth.	Cadmium.
Rose's fusing at 200°	....	25	25	50	....
Fusing at less than 200°	33.3	....	33.3	33.4	....
Newton's, fusing at less than 212°	... .	19	31	50	....
Fusing at 150° to 160°	....	12	25	50	13

Soldering Fluid for use with Soft Solder.—To 2 fluid oz. of muriatic acid add small pieces of zinc until bubbles cease to rise. Add ½ a teaspoonful of sal-ammoniac and 2 fluid oz. of water.

By the application of this to iron or steel, they may be soldered without their surfaces being previously tinned.

FLUXES FOR SOLDERING OR WELDING.

Iron	Borax.
Tinned Iron	Resin.
Copper and Brass	Sal-ammoniac.
Zinc	Chloride of zinc.
Lead	Tallow of resin.
Lead and tin pipes	Resin and sweet oil.

STEEL.—Sal-ammoniac, 1 part; borax, 10 parts. Pound together, and fuse until clear, and, when cool, reduce to powder.

Babbitt's Anti-attrition Metal.—Melt 4 lbs. copper; add, by degrees, 12 lbs. best Banca tin; 8 lbs. regulus of antimony, and 12 lbs. more of tin. After 4 or 5 lbs. tin have been added, reduce the heat to a dull red, then add the remainder of the metal as above.

This composition is termed *hardening;* for lining, take 1 lb. of this *hardening*, melt with it 2 lbs. Banca tin, which produces the lining metal for use. Hence, the proportions for lining metal are 4 lbs. of copper, 8 of regulus of antimony, and 96 of tin.

MISCELLANEOUS NOTES.

DIMENSIONS OF DRAWINGS FOR PATENTS. — United States, all of drawing and signature to be within marginal line of 8 x 13 inches. Leave 1 inch margin, making the paper 10 x 15 inches.

SERVICE TRAIN OF A QUARTERMASTER.—The Quartermaster's train of an army averages 1 wagon to every 24 men; and a well-equipped army in the field, with artillery, cavalry, and trains, requires 1 horse or mule, upon the average, to every 2 men.

A LUMINOUS POINT, to produce a *visual* circle, must have a velocity of 10 feet in a second, the diameter not exceeding 15 inches.

All solid bodies become *luminous* at 800 degrees of heat.

TIDES.—The difference in time between high water averages about 49 minutes each day.

In sandy soil, the greatest force of a pile-driver will not drive a pile over 15 feet.

A FALL of .1 of an inch in a mile will produce a *current* in rivers.

MELTED SNOW produces from ¼ to ⅛ of its bulk in water.

At the depth of 45 feet, the *temperature of the earth* is uniform throughout the year.

A SPERMACETI CANDLE .85 of an inch in diameter consumes an inch in length in 1 hour.

SILICA is the base of the mineral world, and *Carbon* of the organized.

SOUND passes in water at a velocity of 4,708 feet per second.

METALS have five degrees of lustre—*splendent, shining, glistening, glimmering* and *dull.*

A MARBLE-SAW requires half a horse's power.

WIRE AND HEMP ROPES.—A wire rope 3½ ins. in circumference, and a hemp shroud 8 ins. in circumference, parted in the rope at 10½ tons—4,600 lbs. per square inch.

ENDLESS ROPES.—The friction or adhesion of ropes is from .1 to .07 of their weight.

Brief Rules for the Computation of the Weights of Cast Iron Pipes and Cast and Wrought Iron Bolts.—(Horatio Allen.) —CAST IRON PIPES.—To the inner diameter of the pipe add the thickness of the pipe in inches, and multiply the sum by 10 times the thickness, and the product will give the weight in pounds per foot.

WROUGHT IRON BOLTS.—Square the radius of the bolt and multiply it by 10, and the product will give the weight in pounds per foot.

For cast iron, subtract 2-27, or, .074 of the result.

MALLEABLE OR ALUMINUM BRONZE.—By weight: Copper, 90; Aluminum, 10. This composition may be forged either when heated or cooled, and becomes extremely dense. Its tensile strength is 100,000 lbs., and when drawn into wire 128,000 lbs., and its elasticity one half that of wrought iron. Specific gravity, 7700.

STRENGTH OF MATERIALS.

ELASTICITY AND STRENGTH.

The component parts of a rigid body adhere to each other with a force which is termed *cohesion.*

Elasticity is the resistance which a body opposes to a change of form.

Strength is the resistance which a body opposes to a permanent separation of its parts.

Elasticity and *strength*, according to the manner in which a force is exerted upon a body, are distinguished as *tensile strength*, or absolute resistance; *transverse strength*, or resistance to flexure; *crushing strength*, or resistance to compression; *torsional strength*, or resistance to torsion; and *detrusive strength*; or resistance to shearing.

The *limit of stiffness* is flexure, and the limit of strength or resistance is fracture.

Resiliénce, or toughness of bodies, is strength and flexibility combined; hence any material or body which bears the greatest load, and bends the most at the time of fracture, is the toughest.

The *specific gravity* of iron is ascertained to indicate very correctly the relative degree of its strength.

The *neutral axis*, or *line of equilibrium*, is the line at which extension terminates and compression begins.

The *resistance* of cast iron to crushing and tensile strains is, as a mean, as 4, 3 to 1.*

English cast iron has a higher resistance to compression, and a less tensile resistance, than American.

The *mean tensile strength* of American cast iron, as determined by Major Wade for the U. S. Ordnance Corps, is 31,829 lbs. per square inch of section; the mean of English, as determined by Mr. E. Hodgkinson for the Railway Commission, etc., in 1849, is 19,484 lbs.; and by Col. Wilmot at Woolwich, in 1858, for gun-metal, is 23,257 lbs.

The *ultimate extension* of cast iron is the 500th part of its length.

The *mean traverse strength* of American cast iron, also determined by Major Wade, is 681 lbs. per square inch, suspended from a bar fixed at one end and loaded at the other; and the mean of English, as determined by Fairbairn, Barlow, and others, is 500 lbs.

The *resistance of wrought iron* to crushing and tensile strains is, as a mean, as 1·5 to 1 for American; and for English, 1·2 to 1.

The *mean tensile strength* of American wrought iron, as determined by Prof. Johnson, is 55,900 lbs., and the mean of English, as determined by Capt. Brown, Barlow, Brunel, and Fairbairn, is 53,900 lbs.†

The *ultimate extension* of wrought iron is the 600th part of its length.

The *resistance to flexure*, acting evenly over the surface, is nearly ½ the tensile resistance.

Modulus of Elasticity.—The *modulus* or *coefficient of the elasticity* of any substance is the measure of its elastic reaction or force, and is the height of a column of the same substance, capable of producing a pressure on its base, which is to the weight causing a certain degree of compression, as the length of the substance is to the diminution of its length.

It is computed by this analogy: As the extension or diminution of the length of any given substance is to its length in inches, so is the force that produced that extension or diminution to the modulus of its elasticity.

Or, $x : \mathrm{P} :: l : w = \frac{\mathrm{P}}{x}$, x representing the length a substance 1 in. square

*The experiments of Mr. Hodgkinson on iron of low tensile strength gives a mean of 6.595 to 1.

†The results, as given by Mr. Telford, included experiments upon Swedish iron; hence they are omitted in this summary.

and 1 foot in length would be extended or diminished by the force P, and w the weight of the modulus in lbs.

To Compute the Weight of the Modulus of Elasticity of a Substance.—RULE.—As the extension or compression of the length of any substance is to its length, so is the weight that produced that extension or compression to the modulus of elasticity in pounds avoirdupois.

EXAMPLE.—If a bar of cast-iron, 1 inch square and 10 feet in length, is extended .008 inch, with a weight of 1000 lbs., what is the weight of its modulus of elasticity?

$$.008 : 120\ (10 \times 12) :: 1000 : 15{,}000{,}000 \text{ lbs.}$$

NOTE.—When the weight of the modulus of elasticity of a substance is known, the height of it can be readily computed by dividing the weight by the weight of a bar of the substance 1 inch square and 1 foot in length.

Ex. 2.—If a wrought-iron chain, 60 feet in length and .2 inch in diameter, is subjected to a strain of 150 lbs., what will it be extended?

The modulus of elasticity of iron wire is 26,808,000 lbs., and the area of chain $.2^2 \times .7854 = .31416$.

$$\frac{150}{.31416} = 477{,}463 \text{ lbs. per square inch, and } 60 \times 12 = 720 \text{ ins.}$$

$$\text{Then } 477{,}463 \times \frac{120}{26{,}808{,}000} = \frac{343{,}773\ 36}{26{,}808{,}000} = .0128 \text{ inch.}$$

To Compute the Weight when the Height is Given.—RULE.—Multiply the weight of 1 foot in length of the material by the height of the modulus in feet, and the product will give the weight.

To Compute the Height of the Modulus of Elasticity.—RULE.—Divide the weight of the modulus of elasticity of the material by weight of 1 foot of it and the quotient will give the height in feet.

From a series of elaborate experiments by Mr. E. Hodgkinson for the Railway Commission, he deduced the following formulæ for the extension and compression of cast and wrought iron:

CAST-IRON EXTENSION: $13{,}934{,}040 \frac{e}{l} - 2{,}907{,}432{,}000 \frac{e^2}{l^2} = W.$

CAST-IRON COMPRESSION: $12{,}931{,}560 \frac{c}{l} - 522{,}979{,}200 \frac{c^2}{l^2} = W$, e and c representing the extension and compression, and l the length in inches.

ILLUSTRATION.—What weight will extend a bar of cast-iron, 4 inches square and 10 feet in length, to the extent of .2 inch?

$$13{,}934{,}040 \times \frac{2}{120} - 2{,}907{,}432{,}000 \frac{.2^2}{120^2} = 23223.4 - 8076.2 = 15147.2, \text{ which} \times 4 \text{ ins.}$$
$$= 60588.8 \text{ lbs.}$$

MODULUS OF ELASTICITY AND WEIGHT OF VARIOUS SUBSTANCES.

SUBSTANCES.	Height in feet.	Weight in lbs.	SUBSTANCES.	Height in feet.	Weight in lbs.
Ash	4,970,000	1,656,670	Lignum-vitæ	1,850,000	1,080,400
Brass, yellow	2,460,000	8,464,000	Limestone	2,400,000	3,300,000
" wire	4,112,000	14,632,720	Mahogany	6,570,000	2,071.000
Copper, cast	4,800,000	18,240,000	Marble, white	2,150,000	2,508,000
Elm	5,680,000	1,499,500	Oak	4,750,000	1,710,000
Fir, red	8,330,000	2,016,000	Pine, Pitch,	8,700,000	2,430,000
Glass	4,440,000	5,550,000	" White	8,970.000	1,830,000
Gun-metal	2,790.000	8,844,300	Steel, cast	8,530,000	26,650,000
Hempen fibres	5.000,000	170,000	" wire	9,000,090	28,689.000
Ice	6,000,000	2,370,000	Stone, Portland	1,672,000	1.718,800
Iron, cast	5,750.900	1,796,850	Tin, cast	1,053,000	3,510,000
" wrought	7,550.000	25,820.000	Willow	6,200,000	1,426,000
" wire	8,377,000	28,230,500	Yel. Pine, mean	10,500,000	2,100,000
Lead, cast	146,000	720,000	Zinc	4,480,000	13,440,000

The elasticity of Ivory, as compared to Glass, is as .95 to 1.

To Compute the Length of a Prism of a Material which would be severed by its own Weight when Suspended.—Rule.—Divide the tensile resistance of the material by the weight of a foot of it in length, and the quotient will give the length.

Modulus of Cohesion, or Length in Feet required to Tear assunder the following Substances.—Rawhide, 15,375 feet; hemp twine, 75,000 feet; Catgut, 25,000 feet.

Tensile Strength.—*Tensile strength* is the resistance of the fibres or particles of a body to separation. It is therefore proportional to their number, or to the area of its transverse section.

The *fibres of wood* are strongest near the centre of the trunk or limb of a tree.

Cast Iron.—Experiments on cast iron bars give a tensile strength of from 4,000 lbs. to 5,000 lbs. per square inch of its section, as just sufficient to balance the elasticity of the metal, and as a bar of it is extended the 5500th part of its length for every ton of direct strain per square inch of its section, it is deduced that its elasticity is fully excited when it is extended less than the 3000th part of its length, and the extension of it at its limit of elasticiy is estimated at the 1200th part of its length.

The *mean tensile strength*, then, of cast iron being from 16,000 to 20,000 lbs., the *value* of it, when subjected to a tensile strain, may be safely estimated at from ¼ to ⅓ of this, or of its breaking strain.

A bar of cast iron will *contract or expand* .000006173, or the 162000th of its length for each degree of heat; and assuming the extreme range of the temperature in this country 140° (— 20° + 120°), it will contract or expand with this change .0008642, or the 1157th part of its length. It shrinks in cooling from .0104 to .0118 of its length.

It follows, then, that as 2240 lbs. will extend a bar the 5500th

part of its length, the contraction or extension for the 1157th part will be equivalent to a force of 10,648 lbs. (4¾ tons) per square inch of section.

Cast iron (Greenwood) at three successive meltings gave tenacities of 21,300, 30,100, and 35,700 lbs.

Cast iron at 2.5 tons per square inch will extend the same as wrought iron at 5.6 tons.

The *mean tensile strength* of four kinds of English cast iron, as determined by the Commissioners on the Application of Iron to Railway Structures, was 15,711 lbs. per square inch (7.014 tons); and the mean ultimate extension was, for lengths of 10 feet, .1997 inch, being the 600th part of its length; and this weight would compress a bar the 775th part of its length.

Tensile strength of the strongest piece of cast iron ever tested—45,970 lbs. This was a mixture of grades 1, 2, and 3 of Greenwood iron, and at the 3d fusion.

WROUGHT IRON. — Experiments on wrought iron bars give a *tensile strength* of from 18,000 lbs. to 22,400 lbs. per square inch of its section, as just sufficient to balance the elasticity of the metal, and as a bar of it is extended the 10,000th part of its length for every ton of direct strain per square inch of its section, it is deduced that its elasticity is fully excited when it is extended the 1000th part of its length, and the extension of it at its limit of elasticity is estimated at the 1520th part of its length.

The *mean tensile strength* of wrought iron being from 55,000 to 65,000 lbs., the *value* of it, when subjected to a tensile strain, may be safely estimated at from ¼ to ⅓ of this, or of its breaking strain. A bar of wrought iron will *expand or contract* .000006614, or the 151,200th part of its length for each degree of heat; and assuming, as before stated for cast iron, that the extreme range of temperature in the air in this country is 140°, it will contract or expand with this change .000926, or the 1080th of its length, which is equivalent to a force of 20,740 lbs. (9¼ tons) per square inch of section.

Experiments upon wrought iron, to determine the results from repeated heating and laminating, furnished the following:—From 1 to 6 reheating and rollings, the *tensile strength* increased from 43,904 lbs. to 61,824 lbs., and from 6 to 12 it was reduced to 43,904 again.

The *tensile force* of metals varies with their temperature, generally decreasing as the temperature is increased. In silver the tenacity decreases more rapidly than the temperature; in copper, gold, and platinum it decreases less rapidly than the temperature.

In iron, the *tensile strength* at different temperature is as follows: 60°, 1; 114°, 1.14; 212°, 1.2; 250°, 1.32; 270°, 1.35; 325°, 1.41; 435°, 1.4.

STIRLING'S MIXED OR TOUGHENED IRON.—By the mixture of a portion of malleable iron with cast iron, carefully fused in a crucible, a tensile strain of 25,764 lbs. has been attained. This mixture, when judiciously managed and duly proportioned, increases the resistance of cast iron about one-third; the greatest effect being obtained with a proportion of about 30 per cent. of malleable iron.

Bronze (gun-metal) varies in *tenacity* from 23,000 to 54,500 lbs.

ELEMENTS CONNECTED WITH THE TENSILE RESISTANCE OF VARIOUS SUBSTANCES.

SUBSTANCES.	Tensile Strain per Sq. Inch for limit of Elasticity.	Ratio of Strain to that causing Rupture.	SUBSTANCES.	Tensile Strain per Sq. Inch for limit of Elasticity.	Ratio of Strain to that causing Rupture.
	Lbs.			Lbs.	
Beech	3,355	.3	Wrought-iron, Swe.	24,400	.34
Cast-iron, English	4,000	.22	" Eng.	18,850	.35
" American	5,000	.2		22,400	.35
Oak	2,856	.23	" Am.	21,000	.26
Steel plates, blue tempered	93,720	.62	Wrought wire, No. 9, unannealed	47,532	.49
Steel wire	35 700	.5	Wrought wire, No. 9, annealed	36,300	.45
Yellow Pine	3,332	.23			
Wrought-iron, or'dy	17,600	.3			

TENSILE STRENGTH OF MATERIALS.

WEIGHT OR POWER REQUIRED TO TEAR ASUNDER ONE SQUARE INCH.

METALS.

	Lbs.		Lbs.
Copper, wrought	34000	Iron plates, mean, English	51000
" rolled	36000	" " lengthwise	53800
" cast, American	24250	" " crosswise	48800
" wire	61200	" inferior, bar	30000
" bolt	33800	" wire, American	73600
Iron, cast, Low Moor, No. 2	14076	" " " 16 diam	80000
" Clyde, No. 1	16125	" scrap	53400
" " No. 3	23468	Lead, cast	1800
" Calder, No. 1	13735	" milled	3320
" Stirling, mean	25764	" wire	2580
" mean of American	31829	Platinum, wire	53000
" mean* of English	19484	Silver, cast	40000
" Greenwood, Amer'n	45970	Steel, cast, maximum	142000
" gun-metal, mean	37,232	" " mean	88657
" wrought wire	103000	" blistered, soft	133000
" best Swedish bar	72000		104000
" Russian bar	59500	" shear	124000
" English bar	56000	" chrome, mean	170980
" rivets, American	53300	" puddled, extreme	173817
" bolts	52250	" American Tool Co.	179980
" hammered	53913	" plates, lengthwise	96300
" mean of English	53900	" " crosswise	93700
" rivets, English	65000	" razor	150000
" crank shaft	44750	Tin, cast, block	5000
" turnings	55800	" Banca	2122
" plates, boiler, American	45000	Zinc	3500
	62000	" sheet	16000

Lake Superior and Iron Mountain charcoal bloom iron has resisted 90000 lbs. per square inch.

* By Commissioners on Application of Iron to Railway Structures.

MISCELLANEOUS SUBSTANCES.

	Lbs.		Lbs.
Brick, well burned	750	Limestone	670
" fire	65		2800
" inferior	290	Marble, Italian	5200
	100	" white	9000
Cement, blue stone	77	Mortar, 12 years old	60
" hydraulic	234	Plaster of Paris	72
" Harwich	30	Rope, Manilla	9000
" Portland, 6 mos.	414	" hemp, tarred	15000
" Sheppy	24	" wire	37000
" Portland 1, sand 3	380	Sandstone, fine grain	200
Chalk	118	Slate	12000
Glass, crown	2346	Stone, bath	352
Gutta-percha	3500	" Craigleth	400
Hydraulic lime	140	" Hailes	360
" " mortar	140	" Portland	857
Ivory	16000		1000
Leather belts	330	Whalebone	7600

COMPOSITIONS.

	Lbs.		Lbs.
Gold 5, Copper 1	50000	Copper 10, Tin 1	32000
Brass	42000	" 8, Tin 1, gun-metal	30000
" yellow	18000	" 8, " 1, small bars	50000
Bronze, least	17698	Tin 10, Antimony 1	11000
" greatest	56788	Yellow metal	48700

WOODS.

	Lbs.		Lbs.
Ash	14000	Maple	10500
Beech	11500	Oak, American white	11500
Box	20000	" English	10000
Bay	15000	" seasoned	13600
Cedar	11400	" African	14500
Chestnut, sweet	10500	Pear	9800
Cypress	6000	Pine, pitch	12000
Deal, Christiana	12400	" larch	9500
Elm	13400	" American white	11800
Lance	23000	Poplar	7000
Lignum-vitæ	11800	Spruce, white	10290
Locust	20500	Sycamore	13000
Mahogany	21000	Teak	14000
" Spanish	12000	Walnut	7800
" "	8000	Willow	13000

RESULTS OF EXPERIMENTS ON THE TENSILE STRENGTH OF WROUGHT IRON TIE RODS.

Common English Iron, $1\frac{3}{16}$ Inches in Diameter.

Description of Connection.	Breaking Weight.
	Lbs.
Semicircular hook fitted to a circular and welded eye..........	14000
Two semicircular hooks hooked together..............................	16220
Right-angled hook or goose-neck fitted into a cylindrical eye	29120
Two links or welded eyes connected together.........................	48160
Straight rod without any connection articulation................	56000

Iron bars when cold rolled are materially stronger than when only hot rolled, the difference being in some cases as great as 3 to 2.

WIRE ROPES.

RESULT OF EXPERIMENTS ON THE TENSILE STRENGTH OF IRON AND STEEL WIRE ROPES.

Charcoal Iron Wire Rope. Circum.	Weight per foot.	Breaking Weight	Steel Wire Rope. Circum.	Stretch in 6 feet.	Weight per foot.	Breaking Weight.
Ins.	Lbs.	Lbs.	Ins.	Ins.	Lbs.	Lbs.
$1\frac{7}{8}$	$\frac{1}{2}$	13440	$1\frac{15}{16}$	$1\frac{3}{8}$	$\frac{1}{2}$	33600
$3\frac{3}{8}$	$1\frac{1}{2}$	44800	$2\frac{3}{8}$	$\frac{5}{8}$	$\frac{7}{8}$	56000

EXTENSION OF CAST-IRON BARS WHEN SUSPENDED VERTICALLY.

1 Inch Square and 10 Feet in Length. Weight applied at one end.

Weight applied.	Extension.	Set.	Weight applied.	Extension.	Set.
Lbs.	Ins.	Ins.	Lbs.	Ins.	Ins.
529	.0014	....	4234	.0397	.00265
1058	.0092	.000015	8468	.0871	.00855
2117	.0190	.000059	14820	.1829	.02555

Steel.—The tensile strength of steel increases by reheating and rolling up to the second operation, but decreases after that.

The relative resistance of wrought iron and copper to tension and compression is as 100 to 54.5.

Transverse Strength.—*The Transverse or Lateral Strength of any Bar, Beam, Rod, etc.,* is in proportion to the product of its

breadth and the square of its depth; in like-sided beams, bars, etc., it is as the cube of the diameter of the section.

When one end is fixed and the other projecting, the strength is inversely as the distance of the weight from the section acted upon; and the strain upon any section is directly as the distance of the weight from that section.

When both ends are supported only, the strength is 4 times greater for an equal length, when the weight is applied in the middle between the supports, than if one end only is fixed.

When both ends are fixed, the strength is 6 times greater for an equal length, when the weight is applied in the middle, than if one end only is fixed.

The strength of any beam, bar, etc., to support a weight in the centre of it, *when the end rests merely upon two supports*, compared to one *when the ends are fixed*, is as 2 to 3.

When the weight or strain is uniformly distributed, the weight or strain that can be supported, compared with that when the weight or strain is applied at one end or in the middle between the supports, is as 2 to 1.

In metals, the less the dimension of the side of a beam, etc., or the diameter of a cylinder, the greater its proportionate transverse strength. This is in consequence of their having a greater proportion of chilled or hammered surface compared to their elements of strength, resulting from dimensions alone.

The strength of a *cylinder*, compared to a *square* of like diameter or sides, is as 6.25 to 8. The strength of a *hollow cylinder* to that of a *solid cylinder*, of the same length and volume, is as the greater diameter of the former is to the diameter of the latter.

The strength of an *equilateral triangle, fixed at one end and loaded at the other*, having an *edge up*, compared to a *square* of the same area, is as 22 to 27; and the strength of an equilateral triangle, having an *edge down*, compared to one with an *edge up*, is as 10 to 7.

NOTE.—In these comparisons, the beam, bar, etc., is considered as one end being *fixed*, the weight suspended from the other. In Barlow and other authors the comparison is made when the beam, etc., rested upon *supports*. Hence the stress is contrariwise.

Detrusion is the resistance that the particles or fibres of materials oppose to their sliding upon each other. Punching and shearing are detrusive strains.

Deflection.—When a bar, beam etc., is deflected by a cross-strain, the side of the beam, etc., which is bounded by the concave surface, is *compressed*, and the opposite side is *extended.*

In *stones and cast metals*, the resistance to *compression* is greater than the resistance to extension.

In *woods*, the resistance to *extension* is greater than the resistance to compression.

The general law regarding *deflection* is, that it increases, *cœteris paribus*, directly as the cube of the length of the beam, bar, etc., and inversely as the breadth and cube of the depth.

The resistance of *flexure* of a body at its cross-section is very nearly 9-10 of its tensile resistance.

The *stiffest bar or beam* that can be cut out of a cylinder is that of which the depth is to the breadth as the square root of 3 to 1; the *strongest*, as the square root of 2 to 1; and the most *resilient*, that which has the breadth and depth equal.

RELATIVE STIFFNESS OF MATERIALS TO RESIST A TRANSVERSE STRAIN.

Ash	.089	White pine	.1
Beech	.073	Yellow pine	.087
Elm	.079	Wrought iron	1.3
Oak	.095	Cast iron	1.

The strength of a rectangular beam in an *inclined position*, to resist a vertical stress, is to its strength in a horizontal position as the square of radius to the square of the cosine of elevation; that is, as the square of the length of the beam to the square of the distance between its points of support, measured upon a horizontal plane.

Experiments upon bars of cast iron, 1, 2, and 3 inches square, give a result of transverse strength of 447, 348, and 338 lbs. respectively; being in the ratio of 1, .78, and .756.

The *strongest rectangular bar or beam* that can be cut out of a cylinder is one of which the squares of the breadth and depth of it, and the diameter of the cylinder, are as 1, 2, and 3 respectively.

The ratio of the *crushing* to the *transverse* strength is nearly the same in glass, stone, and marble, including the hardest and softest kinds.

Green sand iron castings are 6 per cent. stronger than dry, and 30 per cent. stronger than chilled; but when the castings are chilled and annealed, a gain of 115 per cent. is attained over those made in green sand.

Chilling the under side of cast iron very materially increases its strength.

WOODS.—*Beams of wood*, when laid with their annual or annular layers vertical, are stronger than when they are laid horizontal, in the proportion of 8 to 7.

Woods are *denser at the roots* and at the centre of their trunks. Their strength decreases with the decrease of their density.

TRANSVERSE STRENGTH OF MATERIALS, DEDUCED FROM EXPERIMENTS.

Reduced to the uniform Measure of One Inch Square, and one Foot in Length; Weight suspended from one End.

MATERIALS.	Breaking weight.	Value for general use.
METALS.	Lbs	
Cast iron, American, means of four divisions of grades	507	125 to 160
	622	155 " 210
	733	180 " 240
	772	192 " 250
" mean by Maj. Wade	681	170 " 225
" West Pt. Foundry, extreme	980	250 " 325
" English, Low Moor, cold blast	472	110 " 140
" Ponkey, cold	581	145 " 190
" hot blast, mean	500	125 " 165
" cold " "	516	130 " 170
" Ystalyfera, cold bl't	770	195 " 255
" mean of 65 kinds	500	125 " 165
" mean of 15 kinds, direct from the Pig, cold blast	641	160 " 215
" planed bar	518	130 " 170
" rough bar	531	133 " 175
Steel, greatest	1918	350 " 450
Steel, puddled (permanent bend)	800	170 " 225
WOODS.		
Ash	168	55
Beech	139	32
Birch	160	40
Chestnut	160	53
Deal, Christiana	137	45
Elm	125	30
Hickory	250	55
Locust	295	80
Maple	202	65
Norway pine	123	40
Oak, African	208	50
" American white	230	50
" " live	245	55
" Canadian	146	36
" D	122	30
" Eng	140	35
" " superior	188	45
Pitch pine	136	45
" "	160	50
Riga fir	91	30
Teak	206	60
White pine	92	30
" American	130	45
Whitewood	116	38

MATERIALS.	Breaking weight.	Value for general use.
WROUGHT IRON.	Lbs	
American	700	160 to 209
	650	
	600	
English	400	100 " 130
"	550	135 " 180
Swedish*	665	165 " 210
MIXTURE OF CAST AND WROUGHT IRON, etc.		
Cast iron, Blaenavon	...	145
" 10 per ct. of wr't	...	175
" 30 " "	...	230
" 50 " "	...	185
" and 2½ per ct of nickel, mean	...	180
" Stirling, 2d qu.	...	154
" " 3d "	...	125
Copper	...	55
Brass	...	58
STONES (American).		
Flagging, blue	31.	10
Freestone, Conn	13.	4
" Dorchester	10.8	3½
" N. Jersey	20 1	6½
	17.8	6
" N. York	24.	8
Granite, blue, coarse	18.	6
" Quincy, Mass.	26.	8½
STONES (English).		
Adelaide marble	4.5	1½
Arbroath	17.	5½
Bangor slate	90.	30
Bath	5,2	1¾
Caithness, paving, Sc.	68.	22
Cornish granite	22.	7
Craigleth sandstone	10.7	3½
Darley sandst., Vict'a	1.3	4
Kentish rag	35.8	12
Limestone	11.	3½
Llangollen slate	43.	14
Park Spring sandst'e	4.3	1.4
Portland oolite	21.2	7
Valentia, paving, Irel.	68 5	23
Welsh, "	157.	55
Yorkshire, blue	26.	8½
" landing	22.5	7½
" paving	10.4	3½

INCREASE IN STRENGTH OF SEVERAL WOODS BY SEASONING.

Ash........44.7 per cent.	Elm......12.3 per cent,	White pine....9 per cent.
Beech.....61.9 "	Oak.......26.1 "	

* With 840 lbs. the deflection was 1 inch, and the elasticity of the metal destroyed.

CONCRETES, CEMENTS, ETC.

MATERIALS.	Breaking Weight.	MATERIALS.	Breaking Weight.
CONCRETES (English).		BRICKS (English).	
Fire-brick beam, Portl'd cem't	3.1	Best stock	11.8
" sand, 3 parts: lime, 1 part	.7	Fire-brick	14.
CEMENTS (English).		New brick	10.7
Blue clay and chalk	5.4	Old brick	9.1
Portland {	37.5	Stock-brick, well burned	5.8
	10 2	" inferior, burned	2.5
Sheppy	5.		

TRANSVERSE STRENGTH OF CAST IRON BARS AND OAK BEAMS OF VARIOUS FIGURES.

Reduced to the uniform Measure of One Inch Square of Sectional Area, and One Foot in Length. Fixed at one end, Weight suspended from the other.

FORM OF BAR OR BEAM.	Breaking Weight.	FORM OF BAR OR BEAM.	Breaking Weight.
CAST IRON.	Lbs	 Equilateral triangle, an edge up	Lbs 560
 Square	673	 Equilateral triangle, an edge down	958
 Square, diagonal vertical	568	 2 ins. deep × 2 ins. wide × .268 ins. depth	2068
 Cylinder	573	 2 ins. deep × 2 ins. wide × .268 ins. depth.	565
 Hollow cylinder; greater diameter twice that of lesser	794	OAK.	
 Rectangular prism, 2 ins. deep × ½ in. depth	1456	 Equilateral triangle, an edge up	114
" 3 ins. deep × ⅓ in. depth	2392	 Equilateral triangle, an edge down	130
" 4 " × ¼ "	2652		

TRANSVERSE STRENGTH OF SOLID AND HOLLOW CYLINDERS OF VARIOUS MATERIALS.

One foot in length. Fixed at one end; Weight suspended from the other.

MATERIALS.	Solid External Diameter.	Hollow Internal Diameter.	Breaking Weight.	Breaking Weight for 1 inch external Diameter and proportionate internal Diameter.
WOODS.	Ins.	Ins.	Lbs.	Lbs.
Ash	2.	...	685	86
"	2.	1.	604	75
Fir*	2.	...	772	97
White pine	1.	...	75	75
"	2.	...	610	76
METALS.				
Cast iron, cold blast	3.	...	12000	444
STONE WARE.				
Rolled pipe of fine clay	2.87	1.928	190	8

Brick-work.—A brick arch, having a rise of 2 feet, and a span of 15 feet 9 inches, and 2 feet in width, with a depth at its crown of 4 inches, bore 358,400 lbs. laid along its centre.

To Compute the Transverse Strength of a Rectangular Beam or Bar..—When a Beam or Bar is Fixed at one End, and Loaded at the Other.—*Rule.*—Multiply the *value* of the material in the preceding tables, or as may be ascertained, by the breadth and square of the depth in inches, and divide the product by the length in feet.

Note—When the beam is loaded uniformly throughout its length, the result must be doubled.

Example.—What are the weights each that a cast and wrought iron bar, 2 inches square and projecting 30 inches in length, will bear without permanent injury?

The *values* for cast and wrought iron in this and the following calculations are assumed to be 225 and 180.

Hence $225 \times 2 \times 2^2 = 1800$, which, $\div 2.5 = 720$ lbs.; and $180 \times 2 \times 2^2 = 1440$, which, $\div 2.5 = 576$ lbs.

If the Dimensions of a Beam or Bar are Required to Support a Given Weight at its End.—*Rule.*—Divide the product of the weight and the length in feet by the *value* of the ma-

* An inch-square batten from the same plank as this specimen broke at 139 lbs.

terial, and the quotient will give the product of the breadth and the square of the depth.

EXAMPLE.—What is the depth of a wrought-iron beam, 2 inches broad, necessary to support 576 lbs. suspended at 30 inches from the fixed end?

$\frac{576\times2.5}{180}=8$, which, $\div2$ ins. for the breadth $=4$, and $\sqrt{4}=2$ ins., the breadth.

WHEN A BEAM OR BAR IS FIXED AT BOTH ENDS, AND LOADED IN THE MIDDLE.—*Rule.*—Multiply the *value* of the material by 6 times the breadth and the square of the depth in inches, and divide the product by the length in feet.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE—What weight will a bar of cast iron, 2 inches square and 5 feet in length, support in the middle, without permanent injury?

$$\overline{225}\times2\times6\times2^2=10800, \text{ which}, \div5=2160 \text{ lbs.}$$

OR, IF THE DIMENSIONS OF A BEAM OR BAR ARE REQUIRED TO SUPPORT A GIVEN WEIGHT IN THE MIDDLE, BETWEEN THE FIXED ENDS.—*Rule.*—Divide the product of the weight and the length in feet by 6 times the *value* of the material, and the quotient will give the product of the breadth and the square of the depth.

EXAMPLE.—What dimensions will a cast iron square bar 5 feet in length require to support without permanent injury a stress of 2160 lbs?

$\frac{2160\times5}{225\times6}=\frac{10800}{1350}=8$, which, $\div2$ ins. for the assumed breadth, $=4$, and $\sqrt{4}=$ 2 ins the depth.

WHEN THE BREADTH OR DEPTH IS REQUIRED.—*Rule.*—Divide the product obtained by the preceding rules by the square of the depth, and the quotient is the breadth; or by the breadth, and the square root of the quotient is the depth.

ILLUSTRATION.—If 128 is the product, and the depth is 8: then $128\div8^2=2$, the breadth. Also, $123\div2=64$, and $\sqrt{64}=8$, the depth.

WHEN THE WEIGHT IS NOT IN THE MIDDLE BETWEEN THE ENDS.—*Rule.*—Multiply the *value* of the material by 3 times the length in feet, and the breadth and square of the depth in inches, and divide the product by twice the product of the distances of the weight, or stress from either end.

EXAMPLE.—What is the weight a cast-iron bar, fixed at both ends, 2 ins. square and 5 feet in length, will bear without permanent injury, 2 feet from one end?

$$\frac{225\times3\times5\times2\times2^2}{2\times2\times3}=\frac{27000}{12}=2250 \text{ lbs.}$$

WHEN A BEAM OR BAR IS SUPPORTED AT BOTH ENDS, AND LOADED IN THE MIDDLE.—*Rule.*—Multiply the *value* of the material by 4 times the breadth and the square of the depth in inches, and divide the product by the length in feet.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE.—What weight will a cast-iron bar, 5 feet between the supports, and 2 ins. square, bear in the middle, without permanent injury?

$$225\times\overline{2\times4}\times2^2=7200. \text{ which}, \div 5=1440 \text{ lbs.}$$

OR, IF THE DIMENSIONS ARE REQUIRED TO SUPPORT A GIVEN WEIGHT.—*Rule.*—Divide the product of the weight and length in feet by 3 times the *value* of the material, and the quotient will give the product of the breadth, and the square of the depth.

WHEN THE WEIGHT IS IN THE MIDDLE BETWEEN THE SUPPORTS.—*Rule.*—Multiply the *value* of the material by the length in feet, and the breadth, and the square of the depth in inches, and divide the product by the product of the distances of the weight, or stress from either support.

EXAMPLE.—What weight will a cast-iron bar, 2 ins. square and 5 feet in length, support without permanent injury, at a distance of 2 feet from one end, or support?

$$\frac{225\times5\times2\times2^2}{2\times(5-2)}=\frac{9000}{6}=1500 \text{ lbs.}$$

To Compute the Pressure upon the Ends or upon the Supports.—*Rule.*—1. Divide the product of the weight and its distance from the nearest end or support by the whole length, and the quotient will give the pressure upon the end or support farthest from the weight.

2. Divide the product of the weight and its distance from the farthest end, or support, by the whole length, and the quotient will give the pressure upon the end or support nearest the weight.

EXAMPLE.—What is the pressure upon the supports in the case of the preceding example?

$\frac{1500\times2}{5}=600$ lbs. upon support farthest from the weight; $\frac{1500\times2}{5}=900$ lbs. upon support nearest to the weight.

WHEN A BEAM OR BAR, FIXED OR SUPPORTED AT BOTH ENDS, BEARS TWO WEIGHTS AT UNEQUAL DISTANCES FROM THE ENDS. —Let m and n represent distances of greatest and least weights from their nearest end, W and w greatest and least weights, L whole length, l distance from least weight to farthest end, and l' distance of greatest weight from farthest end.

Then $\frac{m\times W}{L}+\frac{l\times w}{L}=$pressure at w end, and $\frac{n\times w}{L}+\frac{l'\times W}{L}=$pressuro at W end.

ILLUSTRATION.—A beam 10 feet in length, having both ends fixed in a wall, bears two weights, viz., one of 1000 lbs. at 4 feet from one of its ends, and the other of 2000 lbs. at 4 feet from the other end; what is the pressure upon each end?

$\frac{4\times2000}{10}+\frac{6\times1000}{10}=1400$ lbs. pressure upon w end, $\frac{4\times1000}{10}+\frac{6\times2000}{10}=1600$ lbs. pressure at W end.

WHEN THE PLANE OF THE BEAM OR BAR PROJECTS OBLIQUELY UPWARD OR DOWNWARD.—WHEN FIXED AT ONE END AND LOADED AT THE OTHER.—*Rule.*—Multiply the *value* of the material by the breadth and square of the depth in inches, and divide the product by the product of the length in feet and the cosine of the angle of elevation or depression.

NOTE.—When the weight is laid uniformly along its length, the result must be doubled.

EXAMPLE.—What is the weight an ash-beam, 5 feet in length, 3 ins. square, and projecting upward at an angle of 7° 15′, will bear without permanent injury?

$$55 \times 3 \times 3^2 = 1485, \text{ which}, \div \overline{5 \times \cos. 7° 15'}, = 1485 \div \overline{5 \times .992} = 299.39 \text{ lbs.}$$

To Compute the Transverse Strength of Cylinders, Ellipses, etc.—WHEN A CYLINDER, RECTANGLE (THE DIAGONAL BEING VERTICAL,) HOLLOW CYLINDER, OR BEAMS HAVING SECTIONS OF AN ELLIPSE, ARE EITHER FIXED AT ONE END AND LOADED AT THE OTHER, OR SUPPORTED AT BOTH ENDS, THE LOAD APPLIED IN THE MIDDLE, OR BETWEEN THE SUPPORTS.—*Rule.*—Proceed in all cases as if for a rectangular beam, taking for the breadth and depth, and *value* of the material, as follows:

Cylinder, diameter^3 $\times .6$; Rectangle, * side^3 $\times .7$; Hollow Cylinder (diam.^{2}—diam.^{3}) $\times .6$; Ellipse, transverse diam. vertical conj. $\times$ transverse^2, $\times .6$; and Ellipse, conj. diam. vert. transverse $\times$ conj.^{2} $\times .6$ of *value.*

When an Equilaterial Triangle, or ⊤ Beam. RULE.—Proceed in all cases as if for a rectangular beam, taking the following proportions of the *value* of the material.

Fixed at one or both ends.	Equilateral triangle,	edge up,	$b \times d^2$, $\times .2$	of *Value.*
	Equilateral triangle,	edge down,	$b \times d^2$, $\times .34$	"
	⊤ beam or bar,	edge down,	$b \times d^2$, $\times .42$	"
Supported at both ends.	Equilateral triangle,	edge up,	$b \times d^2$, $\times .34$	"
	Equilateral triangle,	edge down,	$b \times d^2$, $\times .2$	"
	⊤ beam or bar,	edge up,	$b \times d^2$, $\times .42$	"

To Compute the Diameter of a Solid Cylinder to Support a Given Weight.—WHEN FIXED AT ONE END, AND LOADED AT THE OTHER.—*Rule.*—Multiply the weight to be supported in pounds by the length of the cylinder in feet; divide the product by .6 of the *value* of the material, and the cube root of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly throughout its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast-iron cylindrical beam, 8 ins. in length, to support 15000 lbs. without permanent injury?

$$3 \text{ ins.} = .66 \text{ feet}; \ \frac{15000 \times .66}{.6 \times 225} = 74.07; \text{ and } \sqrt[3]{74.07} = 4.2.$$

WHEN FIXED AT BOTH ENDS, AND LOADED IN THE MIDDLE.—*Rule.*—Multiply the weight to be supported in pounds by the length

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* The strength of a Rectangle, the diagonal being vertical, compared to that of its circumscribing rectangle, when the direction of the strain is parallel to the side of it, is as 2.45 to 1.

of the cylinder between the supports in feet; divide the product by .6 of the *value* of the material, and the cube root of ¼ of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly along its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast-iron cylinder, 2 feet between the supports, that will support 19305 lbs. without permanent injury?

$$\frac{19305 \times 2}{.6 \times 225} = 286, \text{ and } \sqrt[3]{\frac{286}{6}} = 3.61 \text{ ins.}$$

WHEN SUPPORTED AT BOTH ENDS, AND LOADED IN THE MIDDLE.—*Rule.*—Multiply the weight to be supported in pounds by the length of the cylinder between the supports in feet; divide the product by .6 of the *value* of material, and the cube root of ¼ of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly along its length, the cube root of half quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast-iron cylinder, 2 feet between the supports, that will support 54000 lbs. without permanent injury?

$$\frac{54000 \times 2}{. \times 225} = 800, \text{ and } \sqrt[3]{\frac{800}{4}} = 5.85 \text{ ins.}$$

And what its diameter if loaded uniformly along its length?

$$\frac{800 \div 2}{4} = 100, \text{ and } \sqrt[3]{100} = 4.64 \text{ ins.}$$

To Compute the Relative Value of Materials to resist a Transverse Strain.—Let V represent this value in a Beam, Bar, or Cylinder, one foot in length, and one inch square, side, or in diameter; W the weight; l the length in feet; b the breadth, and d the depth in inches; m the distance of the weight from one end; and n the distance of it from the other in feet.

NOTE.—In cylinders, for $b\, d^2$ put d^3.

1. Fixed at one End, weight suspended from the other, $\frac{l\,W}{b\,d^2} = V$.

2. Fixed at both Ends, weight suspended from the middle, $\frac{l\,W}{6\,b\,d^2} = V$.

3. Supported at both Ends, weight suspended from the middle $\frac{l\,W}{4\,b\,d^2} = V$.

4. Supported at both Ends, weight suspended at any other point than the middle, $\frac{m\,n\,W}{l\,b\,d^2} = V$.

5. Fixed at both Ends, weight suspended at any other point than the middle, $\frac{2\,m\,n\,W}{3\,l\,b\,d^2} = V$.

RELATIVE STRENGTH OF CAST AND MALLEABLE IRON.

It has been found, in the course of the experiments made by Mr. Hodgkinson and Mr. Fairbairn, that the average strain that cast iron will bear in the way of tension, before breaking, is about seven tons and a half per square inch; the weakest, in the course of 16 trials on various descriptions, bearing 6 tons, and the strongest $9\frac{3}{4}$ tons. The experiments of Telford and Brown show that malleable iron will bear, on an average, 27 tons; the weakest bearing 24, and the strongest 29 tons. On approaching the breaking point, cast iron may snap in an instant, without any previous symptom, while wrought iron begins to stretch, with half its breaking weight, and so continues to stretch till it breaks. The experiments of Hodgkinson and Fairbairn show also that cast iron is capable of sustaining compression to the extent of nearly 50 tons on the square inch; the weakest bearing $36\frac{1}{2}$ tons, and the strongest 60 tons. In this respect, malleable iron is much inferior to cast iron. With 12 tons on the square inch it yields, contracts in length, and expands laterally; though it will bear 27 tons, or more, without actual fracture.

Girders, Beams, Lintels, etc.—*The Transverse or Lateral Strength of any Girder, Beam Brest-summer, Lintel,* etc., is in proportion to the product of its breadth and the square of its depth, and also to the area of its cross-section.

The *best form of section* for cast-iron girders or beams, etc., is deduced from the experiments of Mr. E. Hodgkinson, and such as have this form of section ⌶ are known as Hodgkinson's.

The rule deduced from his experiments directs that the area of the bottom flange should be 6 times that of the top flange—flanges connected by a thin vertical web, sufficiently rigid, however, to give the requisite lateral stiffness, and tapering both upward and downward from the neutral axis; and in order to set aside the risk of an imperfect casting, by any great disproportion between the web and the flanges, it should be tapered so as to connect with them, with a thickness corresponding to that of the flange.

As both cast and wrought iron resist crushing or compression with a greater force than extension, it follows that the flange of a girder or beam of either of these metals, which is subjected to a crushing strain, according as the girder or beam is *supported at both*

ends, or fixed at one end, should be of less area than the other flange, which is subjected to extension or a tensile strain.

When *girders are subjected to impulses*, and are used to sustain vibrating loads, as in bridges, etc., the best proportion between the top and bottom flange is as 1 to 4: as a general rule, they should be as narrow and deep as practicable, and should never be deflected to more than one five-hundredth of their length.

In *Public Halls, Churches and Buildings* where the weight of people alone is to be provided for, an estimate of 175 lbs. per square foot of floor surface is sufficient to provide for the weight of flooring and the load upon it.

In churches, buildings, etc., the weight to be provided for should be estimated at that which may at any time be placed thereon, or which at any time may bear upon any portion of their floors; the usual allowance, however, is for a weight of 280 lbs. per square foot of floor surface for stores and factories, and 175 lbs. per square foot when the weight of people alone is to be provided for.

In all uses, such as in buildings and bridges, where the structure is exposed to sudden impulses, the load or stress to be sustained should not exceed from 1-5 to 1-6 of the breaking weight of the material employed; but when the load is uniform or the stress quiescent, it may be increased to ⅓ and ¼ of the breaking weight.

An *open-web girder or beam*, etc., is to be estimated in its resistance on the same principle as if it had a solid web. In cast metals, allowance is to be made for the loss of strength due to the unequal contraction in cooling of the web and flanges.

In *cast-iron*, the mean resistance to *crushing or extension* is as 4.3 to 1, and in wrought iron as 1.35 to 1; hence the mass of metal below the neutral axis will be greatest in these proportions when the stress is intermediate between the ends or supports of the girders, etc.

Wooden girders or beams, when sawed in two or more pieces, and have slips set between them, and the whole bolted together, are made stiffer by the operation, and are rendered less liable to decay.

Girders cast with a face up are stronger than when cast on a side, in the proportion to 1 to .96, and they are strongest also when cast with the bottom flange up.

The following results of the resistances of metals will show how the material should be distributed in order to obtain the *maximum* of strength with the *minimum* of material:

	To Tension	To Crushing.
Cast-iron	21,000 32 000	90,300 140,000
Copper	24,250	117,000
Wrought-iron	45.000 72,000	40,000 83,000

The best iron has the greatest tensile strength, and the least compressive or crushing.

The *most economical construction of a girder or beam*, with reference to attaining the greatest strength with the least material, is as follows: The outline of the top, bottom and sides should be a curve of various forms, according as the breadth or depth throughout is equal, and as the girder or beam is loaded only at one end, or in the middle, or uniformly throughout.

To Compute the Dimensions and Form of a Girder or Beam.—WHEN A GIRDER OR BEAM IS FIXED AT ONE END, AND LOADED AT THE OTHER.—1. *When the depth is uniform throughout the entire length.*—The section at every point must be in proportion to the product of the length, breadth and square of the depth, and as the square of the depth is in every point the same, the breadth must vary directly as the length; consequently, each side of the beam must be a vertical plane, tapering gradually to the end.

2. *When the breadth is uniform throughout the entire length.*—The depth must vary as the square root of the length; hence the upper or lower sides, or both, must be determined by a parabolic curve.

3. *When the section at every point is similar—that is, a Circle, an Ellipse, a Square, or a Rectangle, the sides of which bear a fixed proportion to each other.*—The section at every point being a regular figure, for a circle, the diameter at every point must be as the cube root of the length; and for an ellipse, or a rectangle, the breadth and depth must vary as the cube root of the length.

WHEN A GIRDER OR BEAM IS FIXED AT ONE END AND LOADED UNIFORMLY THROUGHOUT ITS LENGTH.—1. *When the depth is uniform throughout its entire length.*—The breadth must increase as the square of the length.

2. *When the breadth is uniform throughout its entire length.*—The depth will vary directly as the length.

3. *When the section at every point is similar, as a Circle, Ellipse, Square, and Rectangle.*—The section at every point being a regular figure, the cube of the depth must be in the ratio of the square of the length.

WHEN A GIRDER OR BEAM IS SUPPORTED AT BOTH ENDS.—1. *When loaded in the middle.*—The *constant* of the beam, or the product of the breadth and the square of the depth, must be in proportion to the distance from the nearest support; consequently, whether the lines forming the beam are straight or curved, they meet in the centre, and of course the two halves are alike: the beam, therefore, may be considered as one half the length, the supported end corresponding with the free end in the case of beams, one end being fixed, and the middle of the beams similarly corresponding with the fixed end.

2. *When the depth is uniform throughout.*—The breadth must be in the ratio of the length.

3. *When the breadth is uniform throughout.*—The depth will vary as the square root of the length.

4. *When the section at every point is similar, as a Circle, Ellipse,*

Square, and Rectangle.—The section at every point being a regular figure, the cube of the depth will be as the square of the distance from the supported end.

WHEN A GIRDER OR BEAM IS SUPPORTED AT BOTH ENDS, AND LOADED UNIFORMLY THROUGHOUT ITS LENGTH. 1. *When the depth is uniform.*—The breadth will be as the product of the length of the beam and the length of it on one side of the given point, less the square of the length on one side of the given point.

2. *When the breadth is uniform.*—The depth will be as the square root of the product of the length of the beam and the length of it on one side of the given point, less the square of the length on one side of the given point.

3. *When the section at every point is similar, as a Circle, Ellipse, Square, and Rectangle.*—The section at every point being a regular figure, the cube of the depth will be as the product of the length of the beam and the length of it on one side of the given point, less the square of the length on one side of the given point.

GENERAL DEDUCTIONS FROM THE EXPERIMENTS OF STEPHENSON, FAIRBAIRN, CUBITT, HUGHES, ETC. Fairbairn shows in his experiments that with a stress of about 12,320 lbs. per square inch on cast iron, and 28,000 lbs. on wrought iron, the sets and elongations are nearly equal to each other.

A cast-iron beam will be bent to one-third of its breaking weight if the load is laid on gradually; and one-sixth of it, if laid on at once, will produce the same effect, if the weight of the beam is small compared with the weight laid on. Hence beams of cast iron should be made capable of bearing more than 6 times the greatest weight which will be laid upon them.

In wrought-iron beams, if fixed at both ends, the upper flange should be larger than the lower, in the ratio of 1.35 to 1.

The breaking weights in similar beams are to each other as the squares of their like linear dimensions; that is, the breaking weights of beams are computed by multiplying together the area of their section, their depth, and a *constant*, determined from experiments on beams of the particular form under investigation, and dividing the product by the distance between the supports.

Cast and wrought iron beams, having similar resistances, have weights nearly as 2.44 to 1.

The range of the comparative strength of girders of the same depth, having a top and bottom flange, and those having bottom flange alone, is from having but a little area of bottom flange to a large proportion of it, from ½ to ¼ greater strength.

A box beam or girder, constructed of plates of wrought iron, compared to a single rib and flanged beam **I**, of equal weights, has a resistance as 100 to 93.

The resistance of beams or girders, where the depth is greater than their breadth, when supported at top, is much increased. In some cases the difference is fully one third

When a beam is of equal thickness throughout its depth, the

curve should be an *ellipse* to enable it to support a uniform load with equal resistance in every part; and if the beam is an open one, the curve of equilibrium, for a uniform load, should be that of a *parabola*. Hence, when the middle portion is not wholly removed, the curve should be a compound of an ellipse and a parabola, approaching nearer to the latter as the middle part is decreased.

Girders of cast iron, up to a span of 40 feet, involve a less cost than of wrought iron.

Cast iron beams and girders should not be loaded to exceed one-fifth of their breaking weight; and when the strain is attended with concussion and vibration, this proportion must be increased.

Simple cast iron girders may be made 50 feet in length, and the best form is that of Hodgkinson: when subjected to a fixed load, the flange should be as 1 to 6, and when to a concussion, etc., as 1 to 4.

The forms of girders for spaces exceeding the limit of those of simple cast iron are various; the principal ones adopted are those of the straight or arched cast iron girders in separate pieces, and bolted together—the Trussed, the Bow-string, and the wrought iron Box and Tubular.

A *Straight* or *Arched Girder* is formed of separate castings, and is entirely dependent upon the bolts of connection for its strength.

A *Trussed* or *Bow-string Girder* is made of one or more castings to a single piece, and its strength depends, other than upon the depth or area of it, upon the proper adjustment of the tension, or the initial strain, upon the wrought iron truss.

A *Box* or *Tubular Girder* is made of wrought iron, and is best constructed with cast iron tops, in order to resist compression: this form of girder is best adapted to afford lateral stiffness.

Floor Beams, Girders, etc.—The condition of the stress borne by a floor beam is that of a beam supported at both ends and uniformly loaded; but from the irregularity in its loading and unloading, and from the necessity of its possessing great rigidity, it is impracticable to estimate its capacity other than as a beam having the weight borne upon the middle of its length.

To Compute the Depth of a Floor Beam.—WHEN THE LENGTH AND BREADTH ARE GIVEN, AND THE DISTANCE BETWEEN THE CENTRES OF THE BEAM IS ONE FOOT.—*Rule.*—Divide the product of the square of the length in feet and the weight to be borne in pounds per square foot of floor, by the product of 4 times the breadth and the *value* of the material from the Table (page 208,) and the square root of the quotient will give the depth of the beam in inches.

EXAMPLE.—A white pine beam is 2 ins. wide, and 12 feet in length between the supports; what should be the depth of it to support a weight of 175 lbs. per square foot?

$$\frac{12^2 \times 175}{2 \times 4 \times 30} = 105, \text{ and } \sqrt{105} = 10.25 \text{ ins.}$$

WHEN THE DISTANCE BETWEEN THE CENTRES OF THE BEAM IS GREATER OR LESS THAN ONE FOOT.—*Rule.*—Divide the product

of the square of the depth for a beam, *when the distance between the centres is one foot*, by the distance given in inches by 12, and the square root of the quotient will give the depth of the beam in inches.

EXAMPLE.—Assume the beam in the preceding case to be set 15 ins. from the centres of its adjoining beams; what should be its depth?

$$\frac{10.25^2 \times 15}{12} = 131.25, \text{ and } \sqrt{131.25} = 11.45 \text{ ins.}$$

Header and Trimmer Beams.—The conditions of the stress borne or to be provided for by them are as follows:

Header or *Trimmer* beams support ½ of the weight of and upon the tail beams inserted into or attached to them.

Trimmer Beams support, in addition to that borne by them directly as a floor beam, each ½ the weight on the headers.

The stress, therefore, upon a header is due directly to its length, or the number of tail beams it supports; and the stress upon the trimmer beams is that of their own stress as a floor beam, and ½ of the weight upon the header supported by them.

NOTE.—The distance between the support of the trimmer-beams and the point of connection with the header does not in anywise affect the stress upon the trimmer-beams; for in just proportion as this distance is increased, and the stress upon them consequently increased, by the suspension of the header from them nearer to the middle of their length, so is the area of their surface supported by the header reduced, and, consequently, the load to be borne by it.

Girder.—The condition of the stress borne by a Girder* is that of a beam fixed or supported at both ends, as the case may be, supporting the weight borne by all of the beams resting thereon, at the points at which they rest; and its dimensions must be proportionate to the stress upon it, and the distance between its points of insertion or support.

ILLUSTRATION.—It is required to determine the dimensions of a pitch-pine girder, 15 feet between its several points of supports, to support the ends of two lengths of beams each 20 feet in length, having a superincumbent weight, including that of the beams, of 200 lbs. per square foot.

The condition of the stress upon such a girder would be that of a number of beams, 40 feet in length (20×2), supported at both ends, and loaded uniformly along their length, with 200 lbs. upon every superficial foot of their area.

Hence the amount of the weight to be borne is determined by $20 \times 2 \times 15 \times 200 = 120{,}000$ lbs. = the product of twice the length of a beam, the distance between the supports of the girder and the weight borne per square foot of area; and the resistance to be provided for is that to be borne by a beam, 15 feet in length, fixed at both ends, and supporting 120,000 lbs. uniformly laid along its length, equal to 60,000 lbs. supported at its centre.

Consequently, $\frac{15 \times 60{,}000}{6 \times 50} = 3000$ = quotient of the product of the length and weight ÷ the product of 6 times the value of the material; and assuming the girder to be 12 inches wide, then $\sqrt{\frac{3000}{12}} = 15.8$ ins.

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* When a girder has four or more supports, its condition as regards a stress upon its middle is that of a beam fixed at both ends.

THE NEW, OR METRIC SYSTEM OF MEASURES AND WEIGHTS.

Measures of Length.

New System. (U. S. inches. Prior to Law of 1866.)

1 millimetre = .0393707 inches.	1 decametre = 32.80899 feet.
1 centimetre = .3937079 "	1 hectometre = 328.0899 "
1 decimetre = 3.9370797 "	1 kilometre = 1093.633 yards.
1 *metre* = 39.370797 "	1 myriametre = 6.213825 miles.

NOTE.—In the new French system, the values of the base of each measure—viz., Metre, Litre, Stere, Are, and Gramme—are decreased or increased by the following words prefixed to them. Thus,

Milli expresses the 1000th part.	Deca expresses 10 times the value.
Centi " 100th "	Hecto " 100 "
Deci " 10th "	Kilo " 1000 "

Myrio expresses 10000 times the value.

Measures of Surface.

New System.

1 *are* = 1 square decametre = 1076.4309 square feet.
= 100 square metres = 119.6033 square yards.

1 decare = 10 ares. | 1 hectare = 100 ares = 2.4711 acres.

1 square metre = 1550.0599 square inches, or 10.7643 sq. feet.

1 centiare = 10.7643 square feet. | 1 deciare = 11.9603 square yards.

Measures of Volume.

New System.

Decilitre .... = 6.1027 U. S. cubic inches.
Litre .... = 1 cubic decimetre, or 61.0271 cubic inches = 1.05675 U. S. quarts.
Decalitre .... = 610.271 cubic inches.
Kilolitre................ = 35.3166 cubic feet.
Decistere .... = 3.53166 cubic feet.
Stere (a cubic metre) = 35.3166 cubic feet = 61027.0963 cubic inch.
Decastere......... = 353.166 "

Measures of Weight.

New System.

Milligramme = .01543 troy grs.	*Gramme*........ = 15.43316 tr. gr.
Centigramme = .15433 "	Decagramme = 154.33159 "
Decigramme = 1.54331 "	Hectogramme = 1543.3159 "

1 kilogramme................................ = 3.204737 lbs. avoirdupois.
1 myriagramme.............................. = 22.04737 "
1 millier.......... = 1000 kilogrammes = 1 ton sea weight.

453.5688 grammes = .4535688 kilogramme = 1 pound avoirdupois.
372.2223 " = .3732223 " = 1 pound troy.

Transverse Strength of Cast-iron Girders and Beams, Deduced from Experiments in England and America.

Reduced to a Uniform Measure of One Inch in Depth, One Foot in Length, Supported at both Ends; the Stress or Weight applied in the Middle.

Section of Girder or Beam.	Flanges. Top.	Flanges. Bottom.	Width of Vertical Web.	Depth of Girder.	Breadth of Gird'r.	Area of Section in Centre.	Breaking Weight at Length of one foot.	Strength per Sq. Inch of Section.	Value for Breaking Weight $=\frac{l\,W}{A\,d}=V.$‡
	Sq. Ins.	Sq. Ins.	In.	In.	In.	Sq.I.	Lbs.	Lbs.	Lbs.
 Eq. area of flange at top & bottom,	1.75×.42 =.735	1.77×.39 =.69	29	5.125	1.77	2.82	30150	10768	2100
 do.	2.02×.515 =1.045	2.02×.515 =1.045	.51*	2.02	2.02	2.59	10276	3952	1900
 Area of sec. of top & bot. 1 to 6,	2.23×.31 =.72	6.67×.66 =4.4	.266	5.125	6.67	6.23	117450	18852	3650
	....	5 ×.3 =1.5	.365	1.56	5.	1.96	7280	3714	2350
	5 ×.3 =1.5	....	.365	1.56	5.	1.96	2366	1213	760
	....	23.9×3.12 =74.56	3.3	36.1	23.9	183.5	8066240	43958	1200
	5 ×.5 =.25	1.5×.5 =.75	.5	4.†	1.5	1.	19980	19980	5000
	1.5×.5 =.75	.5×.5 =.25	.5	4.†	1.5	1.	7252	7252	1800
	4 × 2 = 8	....	2.	4.	4.	12.	33600	2800	700
	5.1× 2.33 = 11.88	12.1×2.07 =25.04	2.08	30.5	11.1	90.8	4793800	52795	1700
 Rectangular Prism,	....	....	.994	2.012	2.994	2.025	9440	4662	2350
 Open Beam.	1.005×.98	1.005×.99	1 005	2.51	1.005	1.98	12340	6232	2450
	.995×1.01	.995× 1	.995	3.01	.995	2.	15420	7710	2550
	1.005×.98	1.005×.99	1.005	.4	1.005	1.98	21765	10992	2700
	.771×1.51	.771×1.5	.771	4.04	.771	2.322	25705	11070	2750
	1.507×.74	1.507×.74	1.507	4.04	1.507	2.23	25735	11540	2850
	1.525×.78	1.525×.78	1.525	4.07	1.525	2.35	30000	12689	3100
 Square Prism, Stress at Side,	....	....	1.02	1.01	1.02	1.032	2635	2552	2500
 Cylinder, ...	....	... .	1.122	1.122	1.122	.989	2370	2396	2150
 Square Prism, angle up.	....	....	.4431	1.443	1.443	1.041	2269	2182	1500

* Horizontal web. † Depth of opening 3 inches.

‡ A representing area of section, d the depth in inches, l the length in feet, and W the breaking weight in pounds.

CRUSHING STRENGTH OF VARIOUS MATERIALS, DEDUCED FROM EXPERIMENTS IN ENGLAND AND AMERICA.

Reduced to a uniform Measure of One Square Inch.

FIGURES AND MATERIAL.	Crushing Weight.
Prisms.	Lbs.
CAST IRON.	
American, gun-metal	174803
" mean	129000
English, Low Moor, No. 1	62450
" " No. 2	92330
" Clyde, No. 3	106039
" Stirling, mean of all	122395
" " extreme	134400
WROUGHT IRON.	
American	127720
" mean	83500
English	65200
	40000
VARIOUS METALS.	
Fine brass	104800
Cast copper	117000
Cast steel	295000
Cast tin	15500
Lead	7730
WOODS.	
Ash	6663
Beech	6963
Birch	7969
Box	10513
Cedar, red	5968
Chestnut	5350
Elm	6831
Hickory, white	8925
Locust	9113
Mahogany, Spanish	8198
Maple	8150
Oak, American white	6100
" Canadian white	5982
" " live	6850
" English	9500
	6484
Pine, pitch	8947
" white	5775
" yellow	8200
Spruce, white	5950
Sycamore	7082
Teak	12100
Walnut	6645
STONES, CEMENTS, ETC.	
Brick, hard	2000
	4368
" common	4000
	800

FIGURES AND MATERIAL.	Crushing Weight.
	Lbs.
Clay, fine, baked	175
" " rolled and baked	400
Common brick masonry	800
	500
Crown glass	31000
Craigleith Limestone, Eng'h	7300
	2185
Aberdeen granite, "	8400
	10363
Arbroath "	7884
Caithness "	6493
Limestone "	3065
Portland "	15583
	4570
Portland cement "	15000
" mean "	8200
Portland oolite "	3850
Fire-brick, Stourbridge	1717
Freestone, Bellville	3522
" Caen	1088
" Connecticut	3319
" Dorchester	3069
" Little Falls	2991
Gneiss	19600
Granite, Patapsco	5340
" Quincy	15300
Marble, Baltimore, large	8057
" " small	18061
" East Chester*	23917
" Hastings, N. Y	18941
" Italian	12624
" Lee, Mass	22702
" Montgomery co., Pa	8950
" Stockbridge†	10382
" Symington, large	11156
" " fine crystal	18248
" " strata horizontal	10124
" " strata vertical	9324
Mortar, good	240
" common	120
Normandy Caen	1543
Portland cement, 1; sand, 1	1280
Roman "	342
Sandstone, Adelaide	2800
" Acquia Creek‡	5340
" Seneca§	10762
Stock brick	2177
Sydney "	2228

* Same as that of the General Post Office, Washington.
† Same as that of the City Hall. New York.
‡ Same as that of the Capitol, Treasury Department, and Patent Office, Washington, D. C.
§ Same as that of the Smithsonian Institute.
‖ Same as that of the National Washington Monument.

CRUSHING STRENGTH.

The *crushing strength* of any body is in proportion to the area of its section, and inversely as its height. In tapered columns, the strength is determined by the least diameter.

When the height of a *prism or column* is not 5 times its side or diameter, the crushing strength is at its maximum.

Experiments upon *cast-iron bars* give a *crushing stress* of 5,000 lbs. per square inch of section as just sufficient to overcome the elasticity of the metal; and when the height exceeds 3 times the diameter, the iron yields by bending.

When it is 10 times, it is reduced as 1 to 1.75; when it is 15 times, it is reduced as 1 to 2; when it is 20 times, it is reduced as 1 to 3; when it is 30 times, it is reduced as 1 to 4; and when it is 40 times, it is reduced as 1 to 6.

The experiment of Mr. Hodgkinson have determined that an increase of strength of about ⅛ of the breaking weight is obtained by *enlarging the diameter of the column in its middle.*

In cast iron columns of the same thickness, the strength is inversely proportional to the $^{1\cdot7}$ power of the length nearly. Thus in solid columns, the ends being flat, the strength is as $\frac{d^{3\cdot6}}{l^{1\cdot7}}$, l representing the length, and d the diameter.

Hollow columns, having a greater diameter at one end than the other, have not any additional strength over that of uniform cylindrical columns.

Experiment upon *wrought iron* give a *mean crushing stress* of 74,250 lbs. per square inch. Cast iron is decreased in length nearly double what wrought iron is by the same weight; but wrought iron will sink to any degree with little more than 26680 lbs. per square inch, while cast iron will bear 97500 lbs. to produce the same effect.

A *wrought bar* will bear a *compression* of 1-863 of its length, without its utility being destroyed.

With *cast iron*, a pressure beyond 26680 lbs. per square inch is of little, if any, use in practice.

For equal decrements of length, wrought iron will sustain double the pressure of cast iron.

Glass and *the hardest stones* have a *crushing strength* from 7 to 9 times greater than tensile; hence an approximate value of their crushing strength may be obtained from their tensile, and contrariwise.

Various experiments show that the power of *stones*, &c., to resist the effects of *freezing* is a fair exponent of that to resist compression.

WROUGHT IRON PLATES, CYLINDRICAL TUBES.

LENGTH.	Width.	Thickness.	Area.	Crushing Weight.
PLATES.	Ins.	Ins.	Ins.	Lbs.
10 feet	2.98	.497	1.48	815
10 "	3.01	.766	2.3	3379
HOLLOW CYLINDERS.	External.	Internal.		
10 feet	1.495	1.292	.444	14661
10 "	2.49	2.275	.804	29779
10 "	6.366	6.106	2.547	35886
RECTANGULAR TUBES.				
10 lap-riveted	4.1	4.1	.501	10980
10 lap-riveted	4.1	4.1	1.02	19261
10 lap-riveted	4.25	4.25	2.395	21585
10 lap-riveted	8.4	4.25	6.89	29981
10 lap-riveted	8.1	8.1	2.07	132760
10 lap-riveted, and two internal diaphragm plates	8.1	8.1	3.551	19800

EXPANSION OR DILATATION OF SOLIDS.—(FARADAY.)

Lineal.

At 212°, the length of the bar at 32°=1.

Bismuth	1.0013908	Gold	1.001495	Silver	1.00201
Brass	1.0019062	Granite	1.0007894	Slate	1.0011436
Cast iron	1.0011112	Lead	1.0028426	Stock brick	1.0005502
Cement	1.001435	Marble	1.0011041	Steel	1.0011899
Copper	1.001435	Pavements	1.0008985	Tin	1.002
Fire-brick	1.0004928	Platinum	1.0009542	Wrought iron	1.0012575
Glass	1.0008545	Sandstone	1.001743	Zinc	1.002042

DAMS AND TUNNELS.

DAMS (EARTHWORK.)

Width at top in high dams from 7 to 20 ft.	Breast slopes = 3 to 1
Width at top in low dams = height.	Back slopes = 2 to 1

Height above surface of water not less than 3.5 feet.

PROPORTION OF LABORERS IN BANK, FILLERS, AND WHEELERS IN DIFFERENT SOILS, WHEELERS BEING ESTIMATED FOR A DISTANCE OF FIFTY YARDS.

	Getters.	Fillers.	Wheelers.		Getters.	Fillers.	Wheelers.
In loose earth, sand, etc	1	1	1	In hard clay	1	1¼	1¼
In compact earth	1	2	2	In compact gravel	1	1	1
In marl	1	2	2	In rock	3	1	1

MASONRY.

Width at bottom = .7 height; at middle = .5 height; and at top = .3 height.

TUNNELS.—(From Actual Practice in Brickwork.)

PURPOSE.	Formation of Strata.	Extreme Height.		Extreme Width.		Depth at Crown.	
		Feet.	Ins.	Feet.	Ins.	Feet.	Ins.
Canal	Various	16	2	17		1	3
Canal	Clay	21	6	20		1	6
Thames Tunnel	Clay	22	3	37	6	2	6
Railway	Chalk	26	6	27		1	6
"	Various	27	6	27		1	10½
"	Shale	30		30		1	10½
"	Green sand	30	6	30		2	3
"	Freestone	36		36		2	3
Canal	Chalk and earth	39		35	6	1	2

WIND-MILLS.—(Molesworth.)

To Compute the Angles of the Sails.

$23° - \frac{18\,d^2}{r^2}$ = angle of the sail with the plane of motion at any part of the sail; r representing radius of sail in feet, and d distance of any part of the sail from the axis.

Axis of Shaft of Wind-mill with Horizon.

8° upon level ground.
Breadth of whip at axis, $\frac{1}{30}$ length of whip.
Depth " " $\frac{1}{40}$ "
Breadth of whip at end, $\frac{1}{60}$ "
Depth " " $\frac{1}{80}$ "
Width of sail " $\frac{1}{3}$ "

Divided by the whip in the proportion of 5 to 3, the narrowest portion being nearest to the wind.

Width of sail at axis, $\frac{1}{5}$ length of whip; distance of sail from axis, $\frac{1}{7}$ length of whip.

Cross-bars from 16 to 18 inches apart.

STRENGTH OF ICE.

Thickness, 2 ins. will bear infantry.
" 4 " cavalry or light guns.
" 6 " heavy field guns.
" 8 " upon sledges, a weight not exceeding 1000 lbs. per square foot.

STIFFNESS OF BEAMS.

Stiffness of Beams.—(Tredgold.)

$\sqrt[3]{\dfrac{l^2 W C}{b}} = d$; $\dfrac{l^2 W C}{d^3} = b$; b representing breadth, and d depth in inches, l length in feet, and W load in lbs. upon the middle.

C = Pine, .01; Ash, .01; Beech, .013; Elm, .015; Oak, .13; Teak, .008.

When the beam is uniformly loaded, put .625 W instead of W.

Resistance to Detrusion.—When one beam is let in, at an inclination to the depth of another, so as to bear in the direction of the fibres of the beam that is cut, the depth of the cut *at right angles to the fibres* should not be more than one-fifth of the length of the piece, the fibres of which, by their cohesion, resist the pressure.

To Compute the Length necessary to resist a given Horizontal Thrust, as in the Case of a Rafter let into a Tie-Beam.

$\dfrac{4T}{bc} = l$; b representing the breadth of the beam in inches, T the horizontal thrust in lbs., c the cohesive resistance of the material in lbs. per square inch, and l the length in inches.

REVOLVING DISC.

To Compute the Power.—Rule. Multiply one-half the weight of the disc by the height due to the velocity of its circumference in feet per second.

Example.—A grind-stone $3\frac{3}{8}$ feet in diameter, weighing 2000 lbs., is required to make $362\frac{1}{4}$ revolutions per minute; what power must be communicated to it?

Circum. of $3\frac{3}{8}$ = 10.6 feet, which $\times$ 362.25 and $\div$ 60 = 64 feet per second. Then 2000 $\div$ 2 $\times$ 64 = 64000 lbs. raised 1 foot.

Note.—If the revolving disc is not an entire or solid wheel, being a ring or annulus, it must first be computed as if an entire disc, and then the portion wanting must be computed and deducted.

Power Concentrated in Moving Bodies.—Simple power is *force multiplied by its velocity*. Power concentrated in a moving body is the *weight of the body multiplied by the square of its velocity; and the product divided by the acceleratrix*, or the power concentrated in a moving body is equal to the power expended in generating the motion.

SHRINKAGE OF CASTINGS.

		In.
Iron, small cylinders	=	$\frac{1}{16}$ per foot.
" Pipes	=	$\frac{1}{8}$ "
" Girders, beams, etc.	=	$\frac{1}{8}$ in 15 ins.
" Large cylinders, the contraction of diameter at top	=	$\frac{1}{16}$ per foot.
" Ditto at bottom	=	$\frac{1}{12}$ per foot.
" Ditto in length	=	$\frac{1}{8}$ in 16 ins.

Brass, thin.	= $\frac{1}{8}$ in 9 ins.
Brass, thick	= $\frac{1}{8}$ in 10 ins.
Zinc	= $\frac{5}{16}$ in a foot.
Lead	= $\frac{5}{16}$ in a foot.
Copper	= $\frac{3}{16}$ in a foot.
Bismuth	= $\frac{5}{32}$ in a foot.

VERNIER SCALE.

The *Vernier* Scale is 11-10ths, divided into 10 equal parts; so that it divides a scale of 10ths into 100ths when the lines meet in the two scales.

COMPARATIVE WEIGHT OF TIMBER IN A GREEN AND SEASONED STATE.

TIMBER.	Weight of a Cub. Ft.		TIMBER.	Weight of a Cub. Ft.	
	Green.	Seasoned.		Green.	Seasoned.
	Lbs. Oz.	Lbs. Oz.		Lbs. Oz.	Lbs. Oz.
Amer. Pine	44.12	30 11	Cedar	32.	28 4
Ash	58. 3	50.	English Oak	71.10	43 8
Beech	60.	53 6	Riga Fir	48.12	35 8

To Compute the Weight of Cast Metal by the Weight of the Pattern.—When the Pattern is of White Pine.—Rule. Multiply the weight of the pattern in pounds by the following multiplier, and the product will give the weight of the casting:

Iron, 14; Brass, 15; Lead, 22; Tin, 14; Zinc, 13.5.

STRENGTH OF MATERIALS.

Bar of Iron. — The average breaking weight of a Bar of Wrought Iron, 1 inch square, is 25 tons; its elasticity is destroyed, however, by about two-fifths of that weight, or 10 tons. It is extended, within the limits of its elasticity, ·000096, or one-ten-thousandth part of an inch for every ton of strain per square inch of sectional area. Hence, the greatest constant load should never exceed one-fifth of its breaking weight, or 5 tons for every square inch of sectional area.

The *lateral strength* of wrought iron, as compared with cast iron, is as 14 to 9. Mr. Barlow finds that wrought iron bars, 3 inches deep, 1½ inches thick, and 33 inches between the supports, will carry 4½ tons.

Bridges. — The greatest extraneous load on a square foot is about 120 pounds.

Floors. — The least load on a square foot is about 160 pounds.

Roofs. — Covered with slate, on a square foot, 51½ pounds.

Beams. — When a beam is supported in the middle and loaded at each end, it will bear the same weight as when supported at both ends and loaded in the middle; that is, each end will bear half the weight.

Cast Iron Beams should not be loaded to more than one-fifth of their ultimate strength.

The strength of similar beams varies inversely as their lengths; that is, if a beam 10 feet long will support 1000 pounds, a similar beam 20 feet long would support only 500 pounds.

A beam supported at one end will sustain only one-fourth part the weight which it would if supported at both ends.

When a beam is fixed at both ends, and loaded in the middle, it will bear one-half more than it will when loose at both ends. When the beam is loaded uniformly throughout it will bear double. When the beam is fixed at both ends, and loaded uniformly, it will bear triple the weight.

In any beam standing obliquely, or in a sloping direction, its strength or strain will be equal to that of a beam of the same breadth, thickness, and material, but only of the length of the horizontal distance between the points of support.

In the construction of beams, it is necessary that their form should be such that they will be equally strong throughout. If a beam be fixed at one end, and loaded at the other, and the breadth uniform throughout its length, then, that the beam may be equally strong throughout, its form must be that of a parabola. This form is generally used in the beams of steam-engines.

When a beam is regularly diminished towards the points that are least strained, so that all the sections are similar figures, whether it be supported at each end and loaded in the middle, or supported in the middle and loaded at each end, the outline should be a cubic parabola.

When a beam is supported at both ends, and is of the same breadth throughout, then, if the load be uniformly distributed throughout the length of the beam, the line bounding the compressed side should be a semi-ellipse.

The same form should be made use of for the *rails* of a wagonway, where they have to resist the pressure of a load rolling over them.

Similar plates of the same thickness, either supported at the ends or all round, will carry the same weight either uniformly distributed or laid on similar points, whatever be their extent.

The lateral strength of any beam, or bar of wood, stone, metal, etc., is in proportion to its breadth multiplied by its depth^2. In square beams the lateral strengths are in proportion to the cubes of the sides, and in general of like-sided beams as the cubes of the similar sides of the section.

The lateral strength of any beam or bar, one end being fixed in the wall and the other projecting, is inversely as the distance of the weight from the section acted upon; and the strain upon any section is directly as the distance of the weight from that section.

The absolute strength of ropes or bars, pulled lengthwise, is in proportion to the squares of their diameters. All cylindrical or prismatic rods are equally strong in every part, if they are equally thick, but if not they will break where the thickness is least.

The strength of a tube, or hollow cylinder, is to the strength of a solid one as the difference between the fourth powers of the exterior and interior diameters of the tube, divided by the exterior diameter, is to the cube of the diameter of a solid cylinder, —the quantity of matter in each being the same. Hence, from this it will be found, that a hollow cylinder is one-half stronger than a solid one having the same weight of material.

The strength of a column to resist being crushed is directly as the square of the diameter, provided it is not so long as to have a chance of bending. This is true in metals or stone, but in timber the proportion is rather greater than the square.

Models Proportioned to Machines.

The relation of models to machines, as to strength, deserves the particular attention of the mechanic. A model may be perfectly proportioned in all its parts as a model, yet the machine, if constructed in the same proportion, will not be sufficiently strong in every part; hence, particular attention should be paid to the kind of strain the different parts are exposed to; and from the statements which follow, the proper dimensions of the structure may be determined.

If the strain to draw asunder in the model be 1, and if the structure is 8 times larger than the model, then the stress in the structure will be 8^3 equal 512. If the structure is 6 times as large as the model, then the stress on the structure will be 6^3 equal 216, and so on; therefore, the structure will be much less firm than

the model; and this the more, as the structure is cube times greater than the model. If we wish to determine the greatest size we can make a machine of which we have a model, we have,

The greatest weight which the beam of the model can bear, divided by the weight which it actually sustains equal a quotient which, when multiplied by the size of the beam in the model, will give the greatest possible size of the same beam in the structure.

Example. — If a beam in the model be 7 inches long, and bear a weight of 4 lbs., but is capable of bearing a weight of 26 lbs., what is the greatest length which we can make the corresponding beam in the structure? Here

$$26 \div 4 = 6{\cdot}5, \qquad \text{therefore, } 6{\cdot}5 \times 7 = 45{\cdot}5 \text{ inches.}$$

The strength to resist crushing increases from a model to a structure in proportion to their size, but, as above, the strain increases as the cubes; wherefore, in this case, also, the model will be stronger than the machine, and the greatest size of the structure will be found by employing the square root of the quotient in the last rule, instead of the quotient itself; thus,

If the greatest weight which the column in a model can bear is 3 cwt., and if it actually bears 28 lbs., then, if the column be 18 inches high, we have

$$\sqrt{\left(\frac{336}{28}\right)} = 3{\cdot}464; \quad \text{wherefore } 3{\cdot}464 \times 18 = 62{\cdot}362$$

inches, the length of the column in the structure.

TABLE OF MANILLA ROPE.

Diam. Ins.	Circ. Ins.	Wt. per foot. lbs.	Breaking load. Tons.	Breaking load. lbs.	Diam. Ins.	Circ. Ins.	Wt. per foot. lbs.	Breaking load. Tons.	Breaking load. lbs.
·239	¾	·019	·25	560	1·91	6	1·19	11·4	25,536
·318	1	·033	·35	784	2·07	6½	1·39	13·0	29,120
·477	1½	·074	·70	1,568	2·23	7	1·62	14·6	32,704
·636	2	·132	1·21	2,733	2·39	7½	1·86	16·2	36,288
·795	2½	·206	1·92	4,278	2·55	8	2·11	17·8	39,872
·955	3	·297	2·73	6,115	2·86	9	2·67	21·0	47,040
1·11	3½	·404	3·81	8,534	3·18	10	3·30	24·2	54,208
1·27	4	·528	5·16	11,558	3·50	11	3·99	27·4	61,376
1·43	4½	·668	6·60	14,784	3·82	12	4·75	30·6	68,544
1·59	5	·825	8·20	18,368	4·14	13	5·58	33·8	75,712
1·75	5½	·998	9·80	21,952	4·45	14	6·47	37·0	82,880

The strength of Manilla ropes, like that of bar iron, is very variable; and so with hemp ones. The above table supposes an average quality. Ropes of good *Italian* hemp are considerably stronger than Manilla; but their cost excludes them from general use.

Strength of Cordage.—Four-strand cordage is of considerably less strength than three-strand, upon account of the additional hard or twist it receives in the making, four-strand shroud being stronger than four-strand cable. One-thirteenth of the number of the yarns that compose a four-strand rope is a base called a heart, and forms a centre to the rope. The strands being wound spirally round the heart, it becomes a radius, and when the rope is put upon a breaking strain the heart will be the first to break, and where the fracture takes place the strands lose their support and must break.

TABLES OF IRON WIRE ROPE, MANUFACTURED BY JOHN A. ROEBLING'S SONS CO., TRENTON, N. J.

Standard Hoisting Rope, with 19 Wires to the Strand.					Transmission and Standing Rope, with 7 Wires to the Strand.				
Trade No.	Price per foot in cents.*	Circumference in inches.	Breaking strain in tons of 2000 lbs.	Circumference of hemp rope of equal strength.	Trade No.	Price per foot in cents.*	Circumference in inches.	Breaking strain in tons of 2000 lbs.	Circumference of hemp rope of equal strength.
1	1 00	6¾	74	15½	11	48	4⅝	36	10¾
2	78	6	65	14½	12	39	4¼	30	10
3	69	5½	54	13	13	34	3¾	25	9¼
4	58	5	44	12	14	27	3⅜	20	8
5	53	4¾	39	11½	15	23	3	16	7
5½	43	4⅜	33	10¼	16	19	2⅝	12.3	6¼
6	36	4	27	9½	17	14	2⅜	8.8	5¼
7	29	3½	20	8	18	12	2⅛	7.6	5
8	26	3⅛	16	7	19	10½	1⅞	5.8	4¾
9	20	2¾	11.50	6	20	8	1⅝	4.1	4
10	16	2¼	8.64	5	21	7	1⅜	2.83	3¼
10¼	14	2	5.13	4½	22	5½	1¼	2.13	2¾
10½	12	1⅝	4.27	4	23	5	1⅛	1.65	2½
10¾	10	1½	3.48	3½	24	4	1	1.38	2¼
10⅞	8	1¼	2.50	3	25	3½	⅞	1.03	2

Tiller Rope, ¾ in. diam., 21c. per foot; ⅝ in. diam., 16c. per foot; ½ in. diam., 12c. per foot.

Notes on the Use of Wire Rope, by Mr. Roebling.

Two kinds of wire rope are manufactured. The most pliable variety contains nineteen wires in the strand, and is generally used

* Less 30 per cent. discount to consumers.

for hoisting and running rope. The ropes with twelve wires and seven wires in the strand are stiffer, and are better adapted for standing rope, guys and rigging.

For safe working load, allow one-fifth to one-seventh of the ultimate strength, according to speed, so as to get good wear from the rope. When substituting wire rope for hemp rope, it is good economy to allow for the former the same weight per foot which experience has approved for the latter.

Wire rope is as pliable as new hemp rope of the same strength; the former will therefore run over the same sized sheaves and pulleys as the latter. But the greater the diameter of the sheaves, pulleys or drums, the longer wire rope will last. In the construction of machinery for wire rope, it will be found good economy to make the drums and sheaves as large as possible.

Experience has demonstrated that the wear increases with the speed. It is, therefore, better to increase the load than the speed.

Wire rope is manufactured either with a wire or a hemp centre. The latter is more pliable than the former, and will wear better where there is short bending.

Wire rope must not be coiled or uncoiled like hemp rope. When mounted on a reel, the latter should be mounted on a spindle or flat turn-table to pay off the rope. When forwarded in a small coil, without reel, roll it over the ground like a wheel, and run off the rope in that way. All untwisting or kinking must be avoided.

To preserve wire rope, apply raw linseed oil with a piece of sheepskin, wool inside; or mix the oil with equal parts of Spanish brown or lamp-black.

To preserve wire rope under water or under ground, take mineral or vegetable tar, and add one bushel of fresh-slacked lime to one barrel of tar, which will neutralize the acid. Boil it well, and saturate the rope with the hot tar. To give the mixture body, add some saw-dust.

In no case should *galvanized rope* be used for running rope. One day's use scrapes off the coating of zinc, and rusting proceeds with twice the rapidity.

The grooves of cast-iron pulleys and sheaves should be filled with well-seasoned blocks of hard wood, set on end, to be renewed when worn out. This end-wood will save wear and increase adhesion. The smaller pulleys or rollers which support the ropes on inclined planes should be constructed on the same plan. When large sheaves run with very great velocity, the grooves should be lined with leather, set on end, or with India rubber. This is done in the case of all sheaves used in the *transmission of power* between distant points by means of rope, which frequently run at the rate of 4000 feet per minute.

Steel ropes are, to a certain extent, taking the place of iron ropes, where it is a special object to combine lightness with strength.

But in substituting a steel rope for an iron running rope, the object in view should be to gain an increased wear from the rope rather than to reduce the size.

To be serviceable, a steel rope should be of the best obtainable quality, as ropes made from low grades of steel are inferior to good iron ropes.

WEIGHT AND STRENGTH OF IRON CHAINS.

The links of ordinary iron chains are usually made as short as is consistent with easy play, in order that they may not become bent when wound around drums, sheaves, etc.; and that they may be more easily handled in slinging large blocks of stone, etc.

When so made, their weight per foot run is quite approximately $3\frac{1}{2}$ times that of a single bar of the round iron of which they are composed. Since each link consists of two thicknesses of bar, it might be supposed that a chain would possess about double the strength of a single bar; but the strength of the bar becomes reduced about $\frac{3}{10}$, by being formed into links; so that the chain really has but about $\frac{7}{10}$ of the strength of two bars. As a thick bar of iron will not sustain as heavy a load in proportion as a thinner one, so of course stout chains are proportionably weaker than slighter ones. In the following table, 20 tons *per square inch* is assumed as the average breaking strain of a single straight bar of ordinary rolled iron, 1 inch in diameter, or 1 inch square; 19 tons, from 1 to 2 inches; and 18 tons, from 2 to 3 inches. Deducting $\frac{3}{10}$ from each of these, we have as the breaking strain of the two bars composing each link, as follows: 14 tons *per square inch*, up to 1 inch diameter; 13·3 tons, from 1 to 2 inches; and 12·6 tons, from 2 to 3 inches diameter; and upon these assumptions the table is based.

TABLE OF STRENGTH OF CHAINS. (Original.)

Chains of superior iron will require $\frac{1}{4}$ to $\frac{1}{3}$ more to break them.

Diam. of rod of which the links are made.	Weight of chain per ft. run.	Breaking strain of the chain.		Diam. of rod of which the links are made	Weight of chain per ft. run.	Breaking strain of the chain.	
Ins.	Pds.	Pds.	Tons.	Ins.	Pds.	Pds.	Tons.
$\frac{3}{16}$	·325	1,731	·773	1	9·26	49,280	22·00
$\frac{1}{4}$	·579	3,069	1·37	$1\frac{1}{8}$	11·7	59,226	26·44
$\frac{5}{16}$	·904	4,791	2·14	$1\frac{1}{4}$	14·5	73,114	32 64
$\frac{3}{8}$	1·30	6,922	3·09	$1\frac{3}{8}$	17·5	88,301	39·42
$\frac{7}{16}$	1·78	9,408	4·20	$1\frac{1}{2}$	20·8	105,280	47·00
$\frac{1}{2}$	2·31	12,320	5·50	$1\frac{5}{8}$	24·4	123,514	55·14
$\frac{9}{16}$	2·93	15,590	6·96	$1\frac{3}{4}$	28·4	143,293	63·97
$\frac{5}{8}$	3·62	19,219	8·58	$1\frac{7}{8}$	32·6	164,505	73·44
$\frac{11}{16}$	4·38	23,274	10·39	2	37·0	187,152	83·55
$\frac{3}{4}$	5·21	27,687	12·36	$2\frac{1}{4}$	46·9	224,448	100·2
$\frac{13}{16}$	6·11	32,301	14·42	$2\frac{1}{2}$	57·9	277,088	123·7
$\frac{7}{8}$	7·10	37,632	16·80	$2\frac{3}{4}$	70·0	335,328	149·7
$\frac{15}{16}$	8·14	43,277	19·32	3	83·3	398,944	178·1

WEIGHT OF RAILROAD SPIKES.

The hook-headed spikes ***t*****,** commonly used for confining rails to the cross-ties, vary within the limits of the following table; the lightest ones for light rails on short local branches; and the heaviest ones for heavy rails on first-class roads. The table is from the Phœnix Iron Company of Philadelphia. The spikes are sold in kegs usually of 150 pounds. For the weight of spikes of larger dimensions, we may near enough take that of a square bar of the same length. What is saved at the point, suffices for the addition at the head.

Fig. 43.

Size in ins. Length. × Side.	No. per keg of 150 lbs.	No. per lb.	Size in ins. Length. × Side.	No. per keg of 150 lbs.	No. per lb.
$4\frac{1}{2} \times \frac{7}{16}$	526	3·5	$5\frac{1}{2} \times \frac{1}{2}$	350	2·33
$4\frac{1}{2} \times \frac{1}{2}$	400	2·66	$5\frac{1}{2} \times \frac{9}{16}$	289	1·93
$5 \times \frac{3}{8}$	705	4·7	$5\frac{1}{2} \times \frac{5}{8}$	218	1·46
$5 \times \frac{7}{16}$	488	3·25	$6 \times \frac{1}{2}$	310	2·07
$5 \times \frac{1}{2}$	390	2·6	$6 \times \frac{9}{16}$	262	1·75
$5 \times \frac{9}{16}$	295	1·97	$6 \times \frac{5}{8}$	196	1·30
$5 \times \frac{5}{8}$	257	1·71			

A size in very common use is $5\frac{1}{2} \times \frac{9}{16}$, which weighs about $\frac{1}{2}$ pound per spike. A mile of single track road, with 2,112 cross-ties, $2\frac{1}{2}$ feet apart from centre to centre, and with rails of the ordinary length of 24 feet, or 10 ties to a rail, thus having 440 rail-joints per mile, with 4 spikes to each tie, except at the rail-joints, at each of which there will be 4 spikes,† will require, at a neat calculation, 9,328 spikes.

But an allowance must be made for rail guards at road-crossings, which we may assume to be 24 feet wide, or the length of a rail. A guard will usually consist of 4 extra rails for protecting the track rails, and spiked to the 11 ties by which said track rails are sustained. Consequently, such a crossing requires $11 \times 8 = 88$ spikes. For turnouts, sidings, loss, etc., we may roughly average 584‡ spikes more per mile; thus making in all (if we assume one road-crossing per mile) $9328 + 88 + 584 = 10{,}000$ spikes per mile, or 5000 pounds, or $33\frac{1}{3}$ kegs of 150 pounds.

Adhesion of Spikes. — Professor W. R. Johnson found that

† This supposes the joint and chair to rest upon a tie; but when long chairs are used, with a view of placing the rail-joint between two ties laid near each other, there will be 8 spikes to a joint; or 1,760 per mile more than above; equal to 880 pounds; making in all, per mile single track, say 12,000 spikes, or 6,000 pounds, or 40 kegs.

‡ This allows that turnouts and sidings amount to about 1 mile of extra track on 15 miles of road.

a plain spike ·375, or $\frac{3}{8}$ inch square, driven $3\frac{3}{8}$ inches into seasoned Jersey yellow pine, or unseasoned chestnut, required about 2000 pounds force to extract it; from seasoned white oak, about 4000; and from well-seasoned locust, about 6000 pounds. Bevan found that a 6-penny nail, driven one inch, required the following forces to extract it: Seasoned beech, 667 pounds; oak, 507; elm, 327; pine, 187.

Recent careful experiments in Hanover, Germany, by Engineer Funk, give from 2465 to 3940 pounds (mean of many experiments, about 3000 pounds) as the force necessary to extract a plain $\frac{1}{2}$ inch square iron spike, 6 inches long, wedge-pointed for one inch (twice the thickness of the spike), and driven $4\frac{1}{2}$ inches into *white* or *yellow pine.* When driven 5 inches, the force required was about $\frac{1}{10}$ part greater. Similar spikes, $\frac{9}{16}$ inch square, 7 inches long, driven 6 inches deep, required from 3700 to 6745 pounds to extract them from pine; the mean of the results being 4873 pounds. In all cases *about twice as much force was required to extract them from oak.* The spikes were all driven *across* the grain of the wood. Experience shows that when driven *with* the grain, spikes or nails do not hold with much more than half as much force.

Fig. 44.

Jagged spikes, or twisted ones (like an auger), or those which were either swelled or diminished near the middle of their length, all proved inferior to plain square ones. When the length of the wedge point was increased to 4 times the thickness of the spike, the resistance to drawing out was a trifle less.

When the length of the spike is fixed, there is probably no better shape than the plain square cross-section, with a wedge point twice as long as the width of the spike, as per Fig. 44.

Boards of oak or pine, nailed together by from 4 to 16 tenpenny common cut nails, and then pulled apart in a direction lengthwise of the boards, and across the nails, tending to break the latter in two by a shearing action, averaged about 300 to 400 pounds per nail to separate them; as the result of many trials.

WEIGHT OF NAILS.

Name.	Length. Inches.	No. per lb.	Name.	Length. Inches.	No. per lb.
3 penny	1	557	8 penny	$2\frac{1}{2}$	101
4 "	$1\frac{1}{4}$	353	10 "	$2\frac{3}{4}$	68
5 "	$1\frac{3}{4}$	232	12 "	3	54
6 "	2	175	20 "	$3\frac{1}{2}$	34
7 "	$2\frac{1}{4}$	141			

The sizes and weights vary considerably with different makers. The above are machine-made, or CUT NAILS, in distinction to the WROUGHT NAILS made by the blacksmith.

A TABLE

Showing the Weight or Pressure a beam of Cast Iron, 1 *inch in breadth, will sustain, without destroying its elastic force, when it is supported at each end, and loaded in the middle of its length, and also the deflection in the middle which that weight will produce.* By Mr. Hodgkinson, Manchester.

Length.	6 Feet.		7 Feet.		8 Feet.		9 Feet.		10 Feet.	
Depth in in.	Weight in lbs.	Defl. in in.	Weight in lbs.	Defl. in in.	Weight in lbs.	Defl. in in.	Weight in lbs.	Defl. in in.	Weight in lbs.	Defl. in in.
3	1278	·24	1089	·33	954	·426	855	·54	765	·66
3½	1739	·205	1482	·28	1298	·365	1164	·46	1041	·57
4	2272	·18	1936	·245	1700	·32	1520	·405	1360	·5
4½	2875	·16	2450	·217	2146	·284	1924	·36	1721	·443
5	3560	·144	3050	·196	2650	·256	2375	·32	2125	·4
6	5112	·12	4356	·163	3816	·213	3420	·27	3060	·33
7	6958	·103	5929	·14	5194	·183	4655	·23	4165	·29
8	9088	·09	7744	·123	6784	·16	6080	·203	5440	·25
9			9801	·109	8586	·142	7695	·18	6885	22
10			12100	·098	10600	·128	9500	·162	8500	·2
11					12826	·117	11495	·15	10285	·182
12					15264	·107	13680	·135	12240	·17
13							16100	·125	14400	·154
14							18600	·115	16700	·143
	12 Feet.		14 Feet.		16 Feet.		18 Feet.		20 Feet.	
6	2548	·48	2184	·65	1912	·85	1699	1·08	1530	1·34
7	3471	·41	2975	·58	2603	·73	2314	·93	2082	1·14
8	4532	·36	3884	·49	3396	·64	3020	·81	2720	1·00
9	5733	·32	4914	·44	4302	·57	3825	·72	3438	·89
10	7083	·28	6071	·39	5312	·51	4722	·64	4250	·8
11	8570	·26	7346	·36	6428	·47	5714	·59	5142	·73
12	10192	24	8736	·33	7648	·43	6796	·54	6120	·67
13	11971	·22	10260	·31	8978	·39	7980	·49	7182	·61
14	13883	·21	11900	·28	10412	·36	9255	·46	8330	·57
15	15937	·19	13660	·26	11952	·34	10624	·43	9562	·53
16	18128	·18	15536	·24	13584	·32	12080	·40	10880	·5
17	20500	·17	17500	·23	15353	·30	13647	·38	12282	·47
18	22932	·16	19656	·21	17208	·28	15700	·36	13752	·44

NOTE.—This table shows the greatest weight that ever ought to be laid upon a beam for permanent load; and if there be any lia-

bility to jerks, etc., ample allowance must be made; also, the weight of the beam itself must be included. [*See Tables of Cast Iron.*]

To find the Weight of a Cast Iron Beam of given Dimensions.

Rule.—Multiply the sectional area in inches by the length in feet, and by 3·2, the product equal the weight in pounds.

Example.—Required the weight of a uniform rectangular beam of cast iron, 16 feet in length, 11 inches in breadth, and $1\frac{1}{2}$ inch in thickness.

$$11 \times 1{\cdot}5 \times 16 \times 3{\cdot}2 = 844{\cdot}8 \text{ pounds.}$$

Resistance of Bodies to Flexure by Vertical Pressure.

When a piece of *timber* is employed as a column or support, its tendency to yielding by compression is different according to the proportion between its length and area of its cross section; and supposing the form that of a cylinder whose length is less than seven or eight times its diameter, it is impossible to bend it by any force applied longitudinally, as it will be destroyed by splitting before that bending can take place; but when the length exceeds this, the column will bend under a certain load, and be ultimately destroyed by a similar kind of action to that which has place in the transverse strain. Columns of *cast iron* and of other bodies are also similarly circumstanced.

When the length of a *cast iron column* with flat ends equals about thirty times its diameter, fracture will be produced wholly by bending of the material. When of less length, fracture takes place partly by crushing and partly by bending. But, when the column is enlarged in the middle of its length from one and a half to twice its diameter at the ends, by being cast hollow, the strength is greater by one-seventh than in a solid column containing the same quantity of material.

To determine the Dimensions of a Support or Column to bear, without sensible Curvature, a given Pressure in the Direction of its Axis.

Rule.—Multiply the pressure to be supported in pounds by the square of the column's length in feet, and divide the product by twenty times the tabular value of E; and the quotient will be equal to the breadth multiplied by the cube of the least thickness, both being expressed in inches.

Note 1.—When the *pillar or support* is a square, its side will be the fourth root of the quotient.

Note 2.—If the pillar or column be a cylinder, multiply the tabular value of E by 12, and the fourth root of the quotient equal the diameter.

Example 1. — What should be the least dimensions of an oak support, to bear a weight of 2240 pounds, without sensible flexure, its breadth being 3 inches, and its length 5 feet?

$$\text{Tabular value of E} = 105,$$

$$\text{and } \frac{2240 \times 5^2}{20 \times 105 \times 3} = \sqrt[3]{8 \cdot 888} = 2 \cdot 05 \text{ inches.}$$

Example 2.—Required the side of a square piece of Riga fir, 9 feet in length, to bear a permanent weight of 6000 pounds.

$$\text{Tabular value of E} = 96,$$

$$\text{and } \frac{6000 \times 9^2}{20 \times 96} = \sqrt[4]{253} = 4 \text{ inches nearly.}$$

Elasticity of Torsion, or Resistance of Bodies to Twisting.

The angle of flexure by torsion is as the length and extensibility of the body directly and inversely as the diameter; hence the length of a bar or shaft being given, the power, and the leverage the power acts with, being known, and also the number of degrees of torsion that will not affect the action of the machine, to determine the diameter in cast iron with a given angle of flexure.

Rule.—Multiply the power in pounds by the length of the shaft in feet, and by the leverage in feet; divide the product by fifty-five times the number of degrees in the angle of torsion; and the fourth root of the quotient equal the shaft's diameter in inches.

Example.—Required the diameters for a series of shafts 35 feet in length, and to transmit a power equal to 1245 pounds, acting at the circumference of a wheel $2\frac{1}{2}$ feet radius, so that the twist of the shafts on the application of the power may not exceed one degree.

$$\frac{1245 \times 35 \times 2 \cdot 5}{55 \times 1} = \sqrt[4]{1981} = 6 \cdot 67 \text{ inches in diameter.}$$

To determine the Side of a Square Shaft to resist Torsion with a given Flexure.

Rule. — Multiply the power in pounds by the leverage it acts with in feet, and also by the length of the shaft in feet; divide this product by 92·5 times the angle of flexure in degrees, and the square root of the quotient equals the area of the shaft in inches.

Example. — Suppose the length of a shaft to be 12 feet, and to be driven by a power equal to 700 pounds, acting at 1 foot from

the centre of the shaft—required the area of cross section, so that it may not exceed 1 degree of flexure.

$$\frac{700 \times 1 \times 12}{92{\cdot}5 \times 1} = \sqrt[2]{90{\cdot}8} = 9{\cdot}53 \text{ inches.}$$

Relative Strength of Bodies to resist Torsion, Lead being 1.

Tin	1·4	Gun Metal........	5·0	English Iron....	10·1
Copper.............	4·3	Cast Iron.........	9·0	Blistered Steel..	16·6
Yellow Brass	4·6	Swedish Iron....	9·5	Shear Steel......	17·0

STRENGTH OF BEAMS.

[*From Lowndes' Engineer's Hand-Book.*]

Solid, Rectangular, and Round — To find their Strength.

Square and rectangular.

$$\frac{(\text{Depth ins.})^2 \times \text{Thickness ins.}}{\text{Length, ft.}} \times \text{Tabular No.} = \text{Breaking weight,}$$
tons.

Round.

$$\frac{(\text{Diameter ins.})^3}{\text{Length in ft.}} \times \text{Tabular No.} = \text{Breaking weight, tons.}$$

Hollow.

$$\frac{(\text{Outside dia. ins.})^3 - (\text{Inside dia. ins.})}{\text{Length, ft.}} \times \text{Tabular No.} = \text{Breaking}$$
weight, tons.

Thickness not exceeding	1 inch for iron. 3 ins. for wood.	2 ins. for iron. 6 ins. for wood.	3 ins. for iron. 12 ins. for wood.

Square and Rectangular.

Cast and Wrought Iron	·1	·85	·7
Teak and greenheart	·36	·32	·26
Pitch pine, and Canadian oak................	·25	·22	·18
Fir, red pine, and English oak................	·18	·16	·13

Round.

Cast and Wrought Iron	·8	·68	·56
Teak and greenheart...	·28	·25	·2
Fir and English oak...	·14	·125	·1

To find the Breaking Weight in lbs. use the Tabular No. below.

Thickness not exceeding	1 inch for iron. 3 ins. for wood.	2 ins. for iron. 6 ins. for wood.	3 ins. for iron. 12 ins. for wood.

Square and Rectangular.

Iron......................	2240	1900	1570
Teak......................	800	710	570
Fir and oak..............	400	355	285

Round.

Iron......................	1800	1570	1260
Teak......................	640	570	460
Fir and oak..............	320	285	230

Though wrought and cast iron are represented in these rules as of equal strength, it should be observed that while a cast iron bar 1 inch $\times$ 1 inch $\times$ 1 foot 0 inch long, of average quality, will break with one ton, a similar bar of wrought iron only loses its elasticity, and deflects $\frac{1}{16}$ th of an inch, yet as it can only carry a further weight by destroying its shape and increasing the deflection, it is best to calculate on the above basis:

A wrought iron bar 1 in. $\times$ 1 in. $\times$ 1 ft. 0 in. long	deflects	$\frac{1}{16}$	with	1 ton.
		$\frac{1}{8}$	"	$1\frac{1}{4}$ "
		$2\frac{1}{2}$	"	$2\frac{1}{4}$ "

The above rule gives the weight that will break the beam if put on the middle. If the weight is laid equally all over, it would require double the weight to break it.

A beam should not be loaded with more than $\frac{1}{3}$ of the breaking weight in any case, and as a general rule not with more than $\frac{1}{4}$; for purposes of machinery, not with more than $\frac{1}{6}$ to $\frac{1}{10}$, depending on circumstances.

To find the proper size for any given purpose.

Rectangular.

$$\frac{\text{Weight} \times \text{Length ft.}}{\text{Tabular No.}} \times 3 \text{ or } 4 \text{ or } 6\text{, etc., according to circumstances} = \text{B D}^2 \text{ ins.}$$

Round.

$$\sqrt[3]{\frac{\text{Weight} \times \text{Length ft.}}{\text{Tabular No.}}} \times 3 \text{ or } 4 \text{ or } 6\text{, etc., according to circumstances} = \text{Diam. ins.}$$

SOLID COLUMNS.

Fail by crushing with length under..............	5 diameters.
Principally by crushing from......................	5 to 15 "
Partly by crushing, partly by bending, from.	15 to 25 "
Altogether by bending above.........	25 "

Cast iron of average quality is crushed with.....	49	tons	per sq. in.
Wrought iron of average quality is crushed with	16	"	"
Wrought iron is permanently injured with.......	12	"	"
Oak wrought is crushed with.........................	4	"	"
Deal wrought is crushed with.......................	2	"	"

The comparative strength of different columns, of different lengths, will be seen very clearly from the following table derived from experiments by Mr. Hodgkinson:

Wrought Iron Bars.			Proportion of Length to Thickness.	Gave way with
Square.	Length.			
ins.	ft.	ins.		
1 × 1		7½	7½ to 1	21·7 tons per sq. inch.
"	1	3	15 to 1	15·4 " "
"	2	6	30 to 1	11·3 " "
"	5	0	60 to 1	7·5 " "
"	7	6	90 to 1	4·3 " "
½ × ½	5	0	120 to 1	2·5 " "
"	7	6	180 to 1	1· " "

To find the Strength of any Wrought Iron Column with Square Ends.

Area of column sq. inches × tons per inch corresponding to proportion of length, as per table above = Breaking weight, tons.

If the ends are rounded, divide the final result by 3 to find the breaking weight.

In columns of oblong section, the narrowest side must always be taken in calculating the proportion of height to width.

To find the Strength of Round Columns exceeding 25 Diameters in Length. (Mr. Hodgkinson's Rule.)

$$\frac{(\text{Diameter, ins.})^{3\cdot6}}{(\text{Length, ft.})^{1\cdot7}} \times \text{Tabular No.} = \text{Breaking weight, tons.}$$

	Square Ends.	Rounded or Movable Ends.
Wrought iron..................	77	26
Cast iron........................	44	15
Dantzic oak.....................	4·5	1.7
Red deal..........................	3·3	1·2

A column should not be loaded with more than $\frac{1}{3}$ of the breaking weight in any case, and as a general rule, not with more than $\frac{1}{4}$; for purposes of machinery, not with more than $\frac{1}{6}$ to $\frac{1}{10}$, according to circumstances.

TABLES OF POWERS FOR THE DIAMETERS AND LENGTHS OF COLUMNS.

Diameter.	3·6 Power.	Diameter.	3·6 Power.	Length.	1·7 Power.
1 in.	1·	7 in.	1102·04	1	1·
$\frac{1}{4}$	2·23	$\frac{1}{4}$	1251·	2	3·25
$\frac{1}{2}$	4·3	$\frac{1}{2}$	1413·3	3	6·47
$\frac{3}{4}$	7·5	$\frac{3}{4}$	1590·3	4	10·556
2	12·1	8	1782·9	5	15·426
$\frac{1}{4}$	18·5	$\frac{1}{4}$	1991·7	6	21·031
$\frac{1}{2}$	27·	$\frac{1}{2}$	2217·7	7	27·332
$\frac{3}{4}$	38·16	$\frac{3}{4}$	2461·7	8	34·297
3	52·2	9	2724·4	9	41·9
$\frac{1}{4}$	69·63	$\frac{1}{4}$	3006·85	10	50·119
$\frac{1}{2}$	90·9	$\frac{1}{2}$	3309·8	11	58·934
$\frac{3}{4}$	116·55	$\frac{3}{4}$	3634·3	12	68·329
4	147·	10	3981·07	13	78·289
$\frac{1}{4}$	182·9	$\frac{1}{4}$	4351·2	14	88·8
$\frac{1}{2}$	224·68	$\frac{1}{2}$	4745·5	15	99·85
$\frac{3}{4}$	272·96	$\frac{3}{4}$	5165·	16	111·43
5	328·3	11	5610·7	17	123·53
$\frac{1}{4}$	391·36	$\frac{1}{4}$	6083·4	18	136·13
$\frac{1}{2}$	462·71	$\frac{1}{2}$	6584·3	19	149·24
$\frac{3}{4}$	543·01	$\frac{3}{4}$	7114·4	20	162·84
6	632·91	12	7674·5	21	176·92
$\frac{1}{4}$	733·11			22	191·48
$\frac{1}{2}$	844·28			23	206·51
$\frac{3}{4}$	967·15			24	222·

HOLLOW COLUMNS.

Hollow columns fail principally by crushing, provided the length does not exceed 25 diameters; indeed, the length does not appear to affect the strength much till it exceeds 50 diameters.

The comparative strength of different forms and of different thicknesses will appear so distinctly from the experiments below, made by Mr. Hodgkinson, that no difficulty will be found in ascertaining the strength due to any size or form of column that may be required.

SQUARE COLUMNS OF PLATE IRON RIVETED.

Columns 10 feet 0 inches long.

Size.	Thick-ness.	Proportion of Thickness to Width.	Proportion of Length to Width.	Break'g weight Tons per sq. in. of Section.
4 in. × 4 in.	·03	$\frac{1}{133}$	30 to 1	4·9
"	·06	$\frac{1}{66}$	"	8·6
"	·1	$\frac{1}{40}$	"	10·
"	·2	$\frac{1}{20}$	"	12·
8 in. × 8 in.	·06	$\frac{1}{133}$	15 to 1	6·
"	·14	$\frac{1}{60}$	"	9·
"	·22	$\frac{1}{36}$	"	11·5
"	·25	$\frac{1}{32}$	"	12·

Column 8 feet 0 inches long.

18 × 18	·5	$\frac{1}{30}$ practically	5·4 to 1	13·6

Column 10 feet 0 inches long, with cells.

8 in. × 8 in.	·06	$\frac{1}{66}$ of width of cells	15 to 1	8·6

To find the strength of any Hollow Wrought Iron Column.

Sec. area. sq. ins. × Tons per inch, corresponding to the proportions of length and thickness to width as per tables = Breaking weight, tons.

COLUMNS OF OBLONG SECTION.

The strength of these may be ascertained by the same rule as that of square columns. The smallest width being taken in calculating the proportion of height to width, while the longest side must be taken into consideration in calculating the proportion of thickness to width.

Column 10 feet 0 inches long.

Size.	Thickness.	Proportion of Thickness to greatest Width.	Proportion of Length to least Width.	Actual Breaking weight Tons per sq. in. of Section.
8 in. × 4 in.	·06	$\frac{1}{133}$	30 to 1	6·78

ROUND COLUMNS OF PLATE IRON RIVETED.

Columns 10 feet 0 inches long.					*Same Columns Reduced in Length.* Breaking Weights. Tons per square inch.	
Diameter.	Thickness.	Proportion of thickness to Diameter.	Proportion of length to Diameter.	Breaking Weight. Tons per sq. inch.	5 ft. 0 in. long.	2 ft. 6 in. long.
$1\frac{1}{2}$	·1	$\frac{1}{15}$	80 to 1	6·5	13·9	5·8
2	·1	$\frac{1}{20}$	60 to 1	10·35	14·8	16·5
$2\frac{1}{2}$	·1	$\frac{1}{25}$	48 to 1	13·3	15·6	16·3
$2\frac{1}{2}$	·24	$\frac{1}{11}$	48 to 1	9·6	15·6	16·
$2\frac{1}{2}$	·21	$\frac{1}{12}$	48 to 1	9·9	13·	17·
3	·15	$\frac{1}{26}$	40 to 1	12·36	13·	16·5
4	·15	$\frac{1}{26}$	30 to 1	12·34	13·	
6	·1	$\frac{1}{60}$	20 to 1	15·	17·	18·6
6	·13	$\frac{1}{46}$	20 to 1	18·6		

It would seem from this that a thickness of $\frac{1}{48}$, or $\frac{1}{4}$ inch in thickness for every foot in diameter is a good proportion for this kind of column.

It will be seen from these experiments, that it is the proportion of thickness to the width of cell which regulates the strength within certain limits of height.

And that a thickness of $\frac{1}{30}$ or $\frac{1}{8}$ inch for every 4 inches in width will give the highest result practicable for square columns.

CRANE.

The strains on the principal parts can be ascertained with great ease in the following manner — the strength being proportioned accordingly.

To find the Strain on the Post.

$$\frac{\text{Weight suspended, tons} \times \text{Projection, feet}}{\text{Height of post above ground, feet}} = \text{Strain on top of post, tons.}$$

The post can then be calculated as a beam, twice as long as this height from ground, with twice the weight on the middle. [*See Beams.*]

COLD WATER PUMP.

Usually $\frac{1}{4}$ of cylinder diameter when the stroke is $\frac{1}{2}$ that of piston.
$\frac{1}{3}$ " " $\frac{1}{4}$ "

To find the proper size, under any circumstances, capable of supplying twice the quantity ordinarily used for injection.

$$\frac{\text{Cub. ft. water per hour used in cylinder in form of steam}}{\text{Stroke of pump, ft.} \times \text{strokes per minute}} = \text{Area}$$
of pump in square feet.

PEDESTAL — BRACKET.

Pedestal.

Good proportions.

Thickness of cover......	·4	of diameter of bearing.	
" of sole plate	·3	" "	
Diameter of bolts.......	·25	" "	if 2.
" "	·18	" "	if there are 4.

Distance between bolts twice diameter of bearing.

Bracket.

Solid. Metal round brass equal to $\frac{1}{2}$ diameter of bearing.
General thickness web, etc., equal to $\frac{1}{4}$ diameter of bearing.
With Feathers. Width at lightest equal to diameter of bearing.
Thickness equal to $\frac{1}{6}$ " "

FRICTION.

From Mr. Rennie's Experiments.

The friction of metal on metal, without unguents,
May be taken at $\frac{1}{6}$ of the weight up to 40 lbs. per square inch.
" $\frac{1}{5}$ " " 100 "
Brass on cast iron $\frac{1}{4}$ " " 800 "
Wrought on cast iron $\frac{1}{3}$ " " 500 "
With tallow at $\frac{1}{10}$ of the weight.
" olive oil at $\frac{1}{13}$ "
800 lbs. per inch forces out the oil.
Friction of journals under ordinary circumstances $\frac{1}{30}$ of weight.
" well oiled, sometimes only $\frac{1}{60}$ "

CENTRIFUGAL FORCE.

$$\frac{(\text{Revolutions per min.})^2 \times \text{dia. in ft.} \times \text{weight}}{5870} = \text{Centrifugal force}$$
in terms of weight.

WEIGHTS AND VOLUMES OF VARIOUS SUBSTANCES IN ORDINARY USE.

SUBSTANCES.	Cubic Foot.	Cubic Inches
METALS.	Lbs.	Lbs.
Brass. { copper 67. / " zinc 33. }	488.75	.2829
" gun metal..	543.75	.3147
" sheets.........	513.6	.297
" wire............	524.16	.3033
Copper, cast............	547.25	.3179
" plates.........	543.625	.3167
Iron, cast.................	450.437	.2607
" gun metal......	466.5	.27
" heavy forging	479.5	.2775
" plates.............	481.5	.2787
" wrought bars.	486.75	.2816
Lead, cast................	709.5	.4106
" rolled	711.75	.4119
Mercury, 60°............	848.7487	.491174
Steel, plates.............	487.75	.2823
" soft.................	489.562	.2833
Tin..........................	455.687	.2637
Zinc, cast.................	428.812	.2482
" rolled.............	440.437	.2601
WOODS.		Cub. Ft. in a ton.
Ash..........................	52.812	42 414
Bay..........................	51.375	43 601
Cork........................	15.	149.333
Cedar.......................	35.062	63.886
Chestnut..................	38.125	58.754
Hickory, pig nut.....	49.5	45.252
" shell-bark	43.125	51.942
Lignumvitæ............	83.312	26.886
Logwood..................	57.062	39.255
Mahog. Hondur's {	35.	64.
	66.437	33.714
Oak, Canadian........	54.5	41.101
" English...........	58.25	38.455
" live, seasoned	66.75	33.558
" white, dry......	53.75	41.674
" " upland	42.937	52.169
Pine, pitch...............	41.25	54.303
" red,.................	36.875	60.745
" white.............	34.625	64.693
" well seasoned	29.562	75.773

SUBSTANCES.	Cubic Foot.	Cubic Feet in a Ton.
WOODS.	Lbs.	
Pine, yellow...........	33.812	66.248
Spruce.....................	31.25	71.68
Walnut, bl'k, dry..	31.25	71.68
Willow....................	36.562	61.265
" dry...........	30.375	73.744
MISCELLANEOUS.		
Air..........................	.075291	—
Basalt, mean.........	175.	12.8
Brick, fire..............	137.526	16 284
" mean..........	102.	21 961
Coal, anthracite. {	89.75	24.958
	102.5	21.854
" bitum. mean	80.	28.
" Cannel..........	94.875	23 609
" Cumberland	84.687	26.451
" Welsh, mean	81.25	27.569
Coke........................	62.5	35.84
Cotton, bale, mean	14.5	154.48
" " pressd {	20.	114.
	25.	89.6
Earth, clay............	120.625	18.569
" com'n soil..	137.125	16 335
" " gravel	109.312	20.49
" dry, sand...	120.	18.667
" loose..........	93.75	23 893
" moist, sand	128.125	17.482
" mould.........	128.125	17.482
" mud...........	101.875	21.987
" with gravel	126.25	17.742
Granite, Quincy...	165.75	13.514
" Susqueh'na	169.	13.254
Hay, bale...............	9.525	23.517
" pressed	25.	89.6
India rubber..........	56.437	89.60
" vulcanized	—	—
Limestone..............	197.25	11.355
Marble, mean........	167.875	13.343
Mortar, dry, mean	97.98	22.862
Water, fresh..........	62 5	35 84
" salt......... ...	64.125	34 931
Steam......................	.036747	—

WEIGHT OF ONE FOOT OF FLAT BAR IRON.

If a bar of iron be thicker than contained in the table, add together the weight of two numbers, or treble the weight of one number. Wanted the weight of 1 foot of bar iron, 4 inches broad and 2 1-4 inches thick. Opposite 4 and under 1 is 13.364, which doubled is 26.728; add the weight of 1-4th (3.341), equal 30.069 lbs.

Breadth in inches.	THICKNESS IN PARTS OF AN INCH.								
	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1 in.
1	.835	1.044	1.253	1.461	1.670	2.088	2.506	2.923	3.340
1⅛	.939	1.174	1.409	1.644	1.878	2.348	2.818	3.287	3.756
1¼	1.044	1.305	1.566	1.826	2.088	2.609	3.132	3.653	4.176
1⅜	1.148	1.435	1.722	2.009	2.296	2.870	3.444	4.018	4.592
1½	1.252	1.566	1.879	2.192	2.504	3.131	3.758	4.384	5.008
1⅝	1.358	1.696	2.035	2.374	2.716	3.392	4.070	4.749	5.432
1¾	1.462	1.827	2.192	2.557	2.924	3.653	4.384	5.114	5.848
1⅞	1.566	1.957	2.348	2.740	3.132	3.914	4.696	5.479	6.264
2	1.671	2.088	2.505	2.922	3.342	4.175	5.010	5.845	6.684
2⅛	1.775	2.218	2.662	3.105	3.550	4.435	5.324	6.210	7.100
2¼	1.880	2.348	2.818	3.288	3.760	4.696	5.636	6.575	7.520
2⅜	1.984	2.479	2.975	3.470	3.968	4.957	5.950	6.941	7.936
2½	2.088	2.609	3.131	3.653	4.176	5.218	6.262	7.306	8.352
2⅝	2.193	2.740	3.288	3.836	4.386	5.479	6.576	7.671	8.772
2¾	2.297	2.870	3.444	4.018	4.594	5.740	6.888	8.036	9.188
2⅞	2.402	3.001	3.601	4.201	4.804	6.001	7.202	8.402	9.608
3	2.506	3.131	3.758	4.384	5.012	6.262	7.516	8.767	10.024
3¼	2.715	3.392	4.071	4.749	5.430	6.784	8.142	9.498	10.860
3½	2.923	3.653	4.384	5.114	5.846	7.306	8.768	10.228	11.692
3¾	3.132	3.914	4.697	5.479	6.264	7.828	9.394	10.959	12.528
4	3.341	4.175	5.010	5.845	6.682	8.350	10.020	11.690	13.364
4¼	3.549	4.436	5.323	6.210	7.098	8.871	10.646	12.421	14.196
4½	3.758	4.697	5.636	6.575	7.516	9.393	11.272	13.151	15.032
4¾	3.966	4.958	5.949	6.941	7.932	9.915	11.898	13.881	15.864
5	4.175	5.219	6.263	7.306	8.350	10.437	12.526	14.612	16.700
5¼	4.384	5.479	6.576	7.671	8.768	10.958	13.152	15.343	17.536
5½	4.593	5.741	6.889	8.037	9.186	11.480	13.778	16.073	18.372
5¾	4.801	6.001	7.202	8.402	9.602	12.002	14.404	16.804	19.204
6	5.010	6.262	7.515	8.767	10.020	12.524	15.030	17.535	20.042

WEIGHT OF ONE SQUARE FOOT OF SHEET IRON, ETC.

Names.	Thickness by the Birmingham (Eng.) Wire Gauge.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Iron..	12 50	12.00	11.00	10.00	8.74	8.12	7.50	6.86	6.24	5.62	5.00	4.38	3.75	3.12	2.82
Cop...	14.50	13.90	12.75	11.00	10.10	9.40	8.70	7.90	7.20	6.50	5.80	5.08	4.34	3.60	3.27
Brass	13.75	13.20	12.10	11.90	9.61	8.93	8.25	7.54	6.86	6.18	5.50	4.81	4.12	3.43	3.10

Thickness by the Wire Gauge.

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Iron..	2.50	2.18	1.86	1.70	1.54	1.40	1.25	1.12	1.00	.90	.80	.72	.64	.56	.50
Cop ..	2.90	2.52	2.15	1.97	1.78	1.62	1.45	1.30	1.16	1.04	.92	.83	.74	.64	.58
Brass	2.75	2.40	2.04	1.87	1.69	1.54	1.37	1.23	1.10	.99	.88	.79	.70	.61	.55

No. 1 Wire Gauge is 5-16th of an inch; No. 4 is 1-4th; No. 11 is 1-8th; No. 13 is 1-12th; No. 15 is 1-14th; No. 16 is 1-16th; No. 17 is 1-18th; No. 19 is 1-23· No. 22 is 1-32.

RUSSIA SHEET IRON

Measures 56 by 28 inches, and is rated by the weight per sheet. The numbers run from 8 to 18 Russian lbs. per sheet. 8 Russian pounds equal 7.2 English pounds; 9 = 8.1 lbs.; 19=9 lbs.; 11=10 lbs.; 12=11.2 lbs. &c. 100 Russian lbs. equal 90 lbs. English.

WEIGHT OF ONE SQUARE FOOT OF PLATE IRON, ETC.

Thickness in parts of an inch.	Iron.	Copper.	Brass.	Lead.	Thickness in parts of an inch.	Iron.	Copper.	Brass.	Lead.
1/16	2.5	2.9	2.7	3.7	7/16	17.5	20.3	19.0	25.9
1/8	5.0	5.8	5.5	7.4	1/2	20.0	23.2	21.8	29.6
3/16	7.5	8.7	8.2	11.1	5/8	25.0	28.9	27.1	37.0
1/4	10.0	11.6	10.9	14.8	3/4	30.0	34.7	32.5	44.4
5/16	12.5	14.5	13.6	18.5	7/8	35.0	40.4	37.9	57.8
3/8	15.0	17.4	16.3	22.2	1	40.0	46.2	43.3	69.2

WEIGHT ONE FOOT IN LENGTH OF SQUARE AND ROUND BAR IRON.

Side and diameter in inches.	Square iron in pounds.	Round Iron in pounds.	Size and diameter in inches.	Square Iron in pounds.	Round Iron in pounds.	Side and diameter in inches.	Square iron in pounds.	Round Iron in pounds.
1/4	.209	.164	1 5/8	8.820	6.928	3 3/4	46.969	36.895
5/16	.326	.256	1 3/4	10.229	8.043	3 7/8	50.153	39.390
3/8	.470	.369	1 7/8	11.743	9.224	4	53.440	41.984
7/16	.640	.503	2	13.360	10.496	4 1/8	56.833	44.637
1/2	.835	.656	2 1/8	15.083	11.846	4 1/4	60.329	47.385
9/16	1.057	.831	2 1/4	16.909	13.283	4 3/8	63.930	50.211
5/8	1.305	1.025	2 3/8	18.840	14.797	4 1/2	67.637	53.132
11/16	1.579	1.241	2 1/2	20.875	16.396	4 5/8	71.445	56.113
3/4	1.879	1.476	2 5/8	23.115	18.146	4 3/4	75.359	59.187
13/16	2.205	1.732	2 3/4	25.259	19.842	4 7/8	79.378	62.344
7/8	2.558	2.011	2 7/8	27.608	21.684	5	83.510	65.585
15/16	2.936	2.306	3	30.070	23.653	5 1/4	92.459	72.618
1	3.340	2.624	3 1/8	32.618	25.620	5 1/2	101.036	79.370
1 1/8	4.228	3.321	3 1/4	35.279	27.709	5 3/4	110.429	86.731
1 1/4	5.219	4.099	3 3/8	38.045	29.881	6	120.243	94.610
1 3/8	6.315	4.961	3 1/2	40.916	32.170			
1 1/2	7.516	5.913	5 5/8	43.890	34.472			

The weight of bar iron being 1;
" " " cast iron = .95
" " " steel, 1.05
" " " copper, 1.16

CAST IRON.—WEIGHT OF A FOOT IN LENGTH OF SQUARE AND ROUND.

SQUARE.				ROUND.			
Size.	Weight	Size.	Weight	Size.	Weight	Size.	Weight
Inches Square	Pounds	Inches Square	Pounds	Inches Diam.	Pounds	Inches Diam.	Pounds
½	.78	4⅞	74.26	½	.61	4⅞	58.32
⅝	1.22	5	78.12	⅝	.95	5	61.35
¾	1.75	5⅛	82.08	¾	1.38	5⅛	64.46
⅞	2.39	5¼	86.13	⅞	1.87	5¼	67.64
1	3.12	5⅜	90.28	1	2.45	5⅜	70.09
1⅛	3.95	5½	94.53	1⅛	3.10	5½	74.24
1¼	4.88	5⅝	98.87	1¼	3.83	5⅝	77.65
1⅜	5.90	5¾	103.32	1⅜	4.64	5¾	81.14
1½	7.03	5⅞	107.86	1½	5.52	5⅞	84.71
1⅝	8.25	6	112.50	1⅝	6.48	6	88.35
1¾	9.57	6¼	122.08	1¾	7.51	6¼	95.87
1⅞	10.98	6½	132.03	1⅞	8.62	6½	103.69
2	12.50	6¾	142.38	2	9.81	6¾	111.82
2⅛	14.11	7	153.12	2⅛	11.08	7	120.26
2¼	15.81	7¼	164.25	2¼	12.42	7¼	129.
2⅜	17.62	7½	175.78	2⅜	13 84	7½	138.05
2½	19.53	7¾	187.68	2½	15.33	7¾	147.41
2⅝	21.53	8	200.	2⅝	16.91	8	157-08
2¾	23.63	8¼	212.56	2¾	18.56	8¼	167.05
2⅞	25.83	8½	225.78	2⅞	20.28	8½	177.10
3	28.12	8¾	239.25	3	22.18	8¾	187.91
3⅛	30.51	9	253.12	3⅛	23.96	9	198.79
3¼	33.	9¼	267.38	3¼	25.92	9¼	210.
3⅜	35.59	9½	282.	3⅜	27.95	9½	221.50
3½	38.28	9¾	297.07	3½	30.16	9¾	233.31
3⅝	41.06	10	312.50	3⅝	32.25	10	245.43
3¾	43.94	10¼	328.32	3¾	34.51	10¼	257.86
4⅞	46.92	10½	344.53	3⅞	36.85	10½	270.59
4	50.	10¾	361.13	4	39.27	10¾	283.63
4⅛	53.14	11	378.12	4⅛	41.76	11	296.97
4¼	56.44	11¼	395.50	4¼	44.27	11¼	310.63
4⅜	59.81	11½	413.28	4⅜	46.97	11½	324.59
4½	63.28	11¾	431.44	4½	49.70	11¾	338.85
4⅝	66.84	12	450.	4⅝	52.50	12	353.43
4¾	70.50			4¾	55.37		

STEEL.—WEIGHT OF A FOOT IN LENGTH OF FLAT.

Size.	Thick, 1-4 in.	Thick, 3-8ths.	Thick, 1-2 in.	Thick, 5-8ths.	Size.	Thick, 1-4 in.	Thick, 3 8ths	Thick, 1-2 in.	Thick, 5-8ths.
Inch.	lbs.	lbs.	lbs.	lbs.	Inch.	lbs.	lbs.	lbs.	lbs.
1	.852	1.27	1.70	2.13	2½	2.13	3.20	4.26	5.32
1⅛	.958	1.43	1.91	2.39	2¾	2.34	3.51	4.68	5.85
1¼	1.06	1.59	2.13	2.66	3	2.55	3.83	5.11	6.39
1⅜	1.17	1.75	2.34	2.92	3¼	2.77	4.15	5.53	6.92
1½	1.27	1.91	2.55	3.19	3½	2.98	4.47	5.98	7.45
1¾	1.49	2.23	2.98	3.72	3¾	3.19	4 79	6.38	7.98
2	1.70	2.55	3.40	4.26	4	3.40	5.10	6.80	8.52
2¼	1.91	2.87	3.83	4.79					

PATENT IMPROVED LEAD PIPE.

SIZES AND WEIGHT PER FOOT.

Calibre.	Weight per foot		Calibre	Weight per foot		Calibre	Weight per foot		Calibre	Weight per foot		Calibre		Weight per foot	
Inches.	lbs.	oz.	Inches.	lbs.	oz.	Inches.	lbs.	oz.	Inches.	lbs.	oz.	Inches.		lbs.	oz.
⅜		6	½	1	4	¾	1	4	1	4	0	1½		5	0
⅜		8	½	1	8	¾	2	0	1	6	0	1¾		4	0
⅜		10	½	2	0	¾	2	4	1¼	2	8	2		5	0
⅜		12	½	3	0	¾	2	8	1¼	3	0	2		6	0
⅜	1	0	⅝		13	¾	3	0	1¼	3	8	2		7	0
⅜	1	8	⅝	1	0	¾	4	0	1¼	4	0	2½		11	0
½		8	⅝	1	8	1	1	8	1¼	5	0	3		13	0
½		10	⅝	2	0	1	1	12	1½	3	0	3½	¼ in. thick	15	0
½		12	⅝	2	12	1	2	0	1½	3	8	4		18	0
½		14	¾		12	1	2	8	1½	4	0	4½		20	0
½	1	0	¾		14	1	3	0	1½	4	8	5		22	0

Sheet Lead.—Weight of a Square Foot, 2½, 3, 3½, 4, 4½, 5, 6, 7, 8½, 9, 10 lbs., and upwards.

BRASS, COPPER, STEEL AND LEAD.

WEIGHT OF A FOOT.

	BRASS.		COPPER.		STEEL.		LEAD.	
Diam. & side of Square.	Weight of Round.	Weight of Square.	Weight of Round.	Weight of Square.	Weight of Round.	Weight of Square.	Weight of Round.	Weight of Square.
In.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
¼	.17	.22	.19	.24	.17	.21		
⅜	.39	.50	.42	.51	.38	.48		
½	.70	.90	.75	.96	.67	.85		
⅝	1.10	1.40	1.17	1.50	1.04	1.33		
¾	1.59	2.02	1.69	2.16	1.50	1.91		
⅞	2.16	2.75	2.31	2.94	2.05	2.61		
1	2.83	3.60	3.02	3.84	2.67	3.40	3.87	4.93
1⅛	3.58	4.56	3.82	4.86	3.38	4.34	4.90	6.25
1¼	4.42	5.63	4.71	6.	4.18	5.32	6.06	7.71
1⅜	5.35	6.81	5.71	7.27	5.06	6.44	7.33	9.33
1½	6.36	8.10	6.79	8.65	6.02	7.67	8.72	11.11
1⅝	7.47	9.51	7.94	10.15	7.07	9.	10.24	13.04
1¾	8.66	11.03	9.21	11.77	8.20	10.14	11.87	15.12
1⅞	9.95	12.66	10.61	13.52	9.41	11.98	13.63	17.36
2	11.32	14.41	12.08	15.38	10.71	13.63	15.51	19.75
2⅛	12.78	16.27	13.64	17.36	12.05	15.80	17.51	22.29
2¼	14.32	18.24	15.29	19.47	13.51	17.20	19.63	25.
2⅜	15.96	20.32	17.03	21.69	15.05	19.17	21.80	27.80
2½	17.68	22.53	18.87	24.03	16 68	21.21	24.24	30.86
2⅝	19.50	24.83	20.81	26.50	18.39	23.41	26.72	34.02
2¾	21.40	27.25	22.84	29.08	20.18	25.70	29.33	37.34
2⅞	23.39	29.78	24.92	31.79	22.06	28.10	32.05	40.81
3	25.47	32.43	27.18	34.61	24.23	30.60	34.90	44.44

CAST IRON.

WEIGHT OF A SUPERFICIAL FOOT FROM ¼ TO 2 INCHES THICK.

Size.	Weight	Size.	Weight	Size.	Weight	Size.	Weight	Size.	Weight
In.	Lbs.	In.	Lbs.	In.	Lbs.	In.	Lbs.	In.	Lbs.
¼	9.37	⅝	23.43	1	37.50	1⅜	51.56	1¾	65.62
⅜	14.06	¾	28.12	1⅛	42.18	1½	56.25	1⅞	70.31
½	18.75	⅞	32.81	1¼	46.87	1⅝	60.93	2	75.

CAST IRON.

Weight of a Foot in Length of Flat Cast Iron.

Width of Iron.	Thick, ¼ in.	Thick, ⅜ in.	Thick, ½ in.	Thick, ⅝ in.	Thick, ¾ in.	Thick, ⅞ in.	Thick, 1 inch.
Inches.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	1.56	2.34	3.12	3.90	4.68	5.46	6.25
2¼	1.75	2.63	3.51	4.39	5.27	6.15	7.03
2½	1.95	2.92	3.90	4.88	5.85	6.83	7.81
2¾	2.14	3.22	4.29	5.37	6.44	7.51	8.59
3	2.34	3.51	4.68	5.85	7.03	8.20	9.37
3¼	2.53	3.80	5.07	6.34	7.61	8.88	10.15
3½	2.73	4.10	5.46	6.83	8.20	9.57	10.93
3¾	2.93	4.39	5.85	7.32	8.78	10.25	11.71
4	3.12	4.68	6.25	7.81	9.37	10.93	12.50
4¼	3.32	4.97	6.64	8.30	9.96	11.62	13.28
4½	3·51	5.27	7.03	8.78	10.54	12.30	14.06
4¾	3.71	5.56	7.42	9.27	11.13	12.98	14.84
5	3.90	5.86	7.81	9.76	11.71	13.67	15.62
5¼	4.10	6.15	8.20	10.25	12.30	14.35	16.40
5½	4.29	6.44	8.59	10.74	12.89	15.03	17.18
5¾	4.49	6.73	8.98	11.23	13.46	15.72	17.96
6	4.68	7.03	9.37	11.71	14.06	16.40	18.75

WEIGHT.

To find the Weight of any Casting.

Width in $\frac{1}{4}$ ins. $\times$ Thickness in $\frac{1}{8}$ ins., or vice versa, $\div$ 10 $\times$ Length, ft. $=$ Weight, lbs. cast iron.

For instance: to find the weight of a casting $3\frac{1}{4}$ ins. $\times$ $1\frac{1}{8}$ ins. $\times$ 2 ft. 6 ins. long.

$$13 \times 9 \div 10 = 11{\cdot}7 \times 2{\cdot}5 = 29{\cdot}25 \text{ lbs.}$$

This rule is very useful, and can easily be remembered in the following form.

Width in $\frac{1}{4}$ ins. $\times$ Thickness in $\frac{1}{8}$ ins. or vice versa, cut off 1 figure for decimal, the result is lbs. per foot of length.

For wrought iron add $\frac{1}{20}$th to the result; for lead add $\frac{1}{2}$; for brass add $\frac{1}{7}$th; for copper add $\frac{1}{5}$th.

To find the Weight from the Areas.

Area, sq. ins. $\times$ Length, ft. $\times$ $3\frac{1}{7}$ $=$ Weight, lbs. cast iron.

Multiplier for Cast iron.................. 3·156 or $3\frac{1}{7}$.
" Wrought iron........... 3·312 or $3\frac{1}{3}$.
" Lead....................... 4·854.
" Brass...................... 3·644.
" Copper.................... 3·87.

Or, Area, sq. ins. $\times$ 10 $=$ lbs. per yard for wrought iron.

LOGS REDUCED TO ONE INCH BOARD MEASURE.

If the log is longer than is contained in the table, take any two lengths.

The first column on the left gives the length of the log in feet. The figures under D denote the diameters of the logs in inches. Fractional parts of inches are not given.

The diameter of timber is usually taken 20 feet from the butt. All logs short of 20 feet, take the diameter at the top, or small end.

To find the number of feet of boards which a log will produce when sawed, take the length of feet in the first column on the left hand, and the diameter at the top of the page in inches.

Suppose a log 12 feet long and 24 inches in diameter; in the left hand column is the length, and opposite 12 under 24 is 300, the number of feet of boards in a log of that length and diameter.

Lng ft	D. 12	D. 13	D. 14	D. 15	D. 16	D. 17	D. 18	D. 19	D. 20	D. 21	D. 22	D. 23	D. 24
10	54	66	76	93	104	170	137	154	176	194	210	237	256
11	59	72	83	102	114	131	151	169	196	213	231	261	270
12	64	78	90	111	124	143	164	184	214	232	252	285	300
13	69	84	97	120	134	154	177	199	231	251	273	308	327
14	74	90	104	129	144	166	191	214	249	270	293	332	350
15	79	96	111	138	154	177	204	229	266	289	314	355	376
16	84	102	118	146	164	189	217	244	284	308	335	379	401
17	89	108	126	155	173	200	231	259	301	327	356	402	426
18	94	114	133	164	183	212	244	274	319	346	377	426	451
19	99	121	140	173	193	223	257	289	336	365	398	449	477
20	104	127	147	182	203	236	271	304	354	384	419	473	501
21	109	133	154	191	213	247	284	319	371	403	440	497	527
22	114	139	161	200	223	259	297	334	389	422	461	520	552
23	119	145	168	209	233	270	311	349	407	441	481	542	568
24	124	151	176	218	243	282	324	364	424	460	502	563	613
25	129	157	183	227	253	293	337	379	442	479	523	591	628
26	134	163	190	236	263	305	350	394	459	498	544	615	653
27	139	169	197	245	273	316	363	409	477	517	565	639	678
28	144	175	204	254	283	328	376	424	491	536	586	663	703
29	149	181	211	263	293	339	389	439	512	555	607	687	728
30	154	187	218	272	303	351	402	454	529	574	628	711	753
31	159	193	225	281	313	362	415	469	547	593	649	735	778

Lng ft	D. 25	D. 26	D. 27	D. 28	D. 29	D. 30	D. 31	D. 32	D. 33	D. 34	D. 35	D. 36
10	283	309	339	359	377	407	440	456	486	496	543	573
11	311	340	374	396	415	447	484	502	535	546	598	630
12	340	371	408	432	453	489	528	548	584	596	653	688
13	369	404	442	469	491	530	572	594	633	646	708	746
14	397	435	476	505	529	571	618	640	682	696	762	803
15	426	465	511	541	567	612	662	686	731	746	817	861
16	455	496	545	578	605	653	706	732	780	796	872	919
17	483	527	579	614	643	694	751	778	829	846	927	976
18	512	558	613	650	681	735	795	824	878	896	981	1034
19	541	590	647	688	719	776	839	870	927	946	1036	1092
20	569	621	681	724	757	817	884	916	976	996	1091	1148
21	598	652	716	760	796	859	928	962	1025	1046	1146	1206
22	627	684	750	796	834	900	972	1008	1074	1096	1200	1264
23	665	715	784	833	872	941	1017	1054	1123	1146	1255	1318
24	684	746	818	869	910	982	1061	1100	1172	1196	1310	1376
25	713	777	853	906	948	1023	1105	1146	1221	1246	1365	1434
26	742	808	887	942	986	1064	1149	1192	1270	1296	1420	1492
27	771	839	921	979	1024	1105	1193	1238	1319	1336	1475	1550
28	800	870	955	1015	1063	1146	1237	1284	1368	1396	1530	1608
29	829	901	989	1052	1100	1187	1281	1330	1417	1446	1585	1666
30	858	932	1023	1088	1138	1228	1325	1376	1466	1496	1640	1724
31	887	963	1057	1125	1176	1269	1369	1422	1515	1546	1695	1782

SOLID CONTENTS OF EQUAL-SIDED TIMBER.

If the log is shorter than is contained in the table, take half or quarter of some length; if longer, double some length. The length of the log is given on the top of the columns, the diameter in the left hand column. To obtain the cubical contents of masts, spars, round logs, &c., subtract one-fourth from the contents.

In. Di. m.	L. ft. 9	L. 10	L. 11	L. 12	L. 13	L. 14	L. 15	L. 16	L. 17	L. 18	L. 19	L. 20
6	2 3	2 6	2 9	3 0	3 3	3 6	3 9	4 0	4 3	4 6	4 9	5 0
7	3 0	3 4	3 7	4 1	4 5	4 9	5 1	5 5	5 9	6 2	6 6	6 10
8	4 1	4 4	4 10	5 4	5 9	6 2	6 7	8 0	8 5	8 10	9 3	9 8
9	5 2	5 9	6 2	6 9	7 4	7 11	8 6	9 1	9 8	10 3	10 10	11 5
10	6 2	6 10	7 8	8 4	9 0	9 8	10 4	11 0	11 8	12 4	13 0	13 8
11	7 6	8 4	9 3	10 1	10 11	11 9	12 7	13 5	14 3	15 1	15 11	16 9
12	9 0	10 0	11 0	12 0	13 0	14 0	15 0	16 0	17 0	18 0	19 0	20 0
13	10 4	11 7	12 10	14 1	15 3	16 5	17 9	18 9	19 11	21 1	22 3	23 5
14	12 2	13 7	14 11	16 4	17 8	18 11	20 3	21 7	22 11	24 3	25 7	26 11
15	14 2	15 9	17 2	18 9	20 4	21 10	23 5	25 0	26 7	28 2	29 9	31 4
16	16 0	17 10	19 6	21 4	23 1	24 10	26 7	28 4	30 1	21 10	33 7	35 4
17	18 0	20 0	2 0	24 1	26 1	28 1	30 1	32 1	34 1	36 1	38 1	40 1
18	20 3	22 6	24 9	27 0	29 3	31 6	33 9	36 0	38 3	40 6	42 9	45 0
19	22 6	25 0	7 6	30 1	32 7	35 1	37 7	41 1	43 7	46 1	48 7	52 0
20	25 0	27 10	30 10	33 4	36 1	38 10	41 7	44 4	47 2	50 0	52 6	55 9
21	27 7	30 8	33 9	36 9	39 10	42 11	46 0	49 1	52 2	55 3	58 4	61 5
22	30 2	33 6	36 10	40 4	43 8	47 0	50 4	53 8	57 0	60 4	63 8	67 0
23	33 0	36 8	40 4	44 1	47 9	51 5	55 1	58 9	62 5	66 1	69 9	73 5
24	36 0	40 0	44 0	48 0	52 0	56 0	60 0	64 0	68 0	72 0	76 0	80 0
25	39 0	43 4	48 1	52 1	56 5	60 9	65 1	69 5	73 9	78 1	82 5	86 9
26	42 2	46 11	51 7	56 4	61 0	65 8	70 4	75 0	79 8	84 4	89 0	93 8
27	45 7	50 8	55 9	60 9	65 10	70 11	76 0	81 1	86 2	91 7	96 8	101 11
28	49 0	54 5	59 10	65 4	70 9	76 2	81 7	85 0	92 5	97 10	103 3	108 8
29	52 6	58 4	64 2	70 1	75 11	81 9	87 7	93 5	99 3	106 1	112 11	117 [illegible]
30	55 9	62 0	68 3	75 0	81 3	87 6	93 9	100 0	106 3	112 6	118 9	125 [illegible]

WHEEL GEARING.

The **Pitch Line** of a wheel, is the circle upon which the pitch is measured, and it is the circumference by which the diameter, or the velocity of the wheel, is measured.

The **Pitch**, is the arc of the circle of the pitch line, and is determined by the number of the teeth in the wheel.

The **True Pitch** (*Chordial*), or that by which the dimensions of the tooth of a wheel are alone determined, is a straight line drawn from the centres of two contiguous teeth upon the pitch line.

The **Line of Centres**, is the line between the centres of two wheels.

The **Radius** of a wheel, is the semi-diameter running to the periphery of a tooth. The *Pitch Radius*, is the semi-diameter running to the pitch line.

The **Length of a Tooth**, is the distance from its base to its extremity.

The **Breadth of a Tooth**, is the length of the face of wheel.

A **Cog Wheel**, is the general term for a wheel having a number of cogs or teeth set upon or radiating from its circumference.

A **Mortise Wheel**, is a wheel constructed for the reception of teeth or cogs, which are fitted into recesses or sockets upon the face of the wheel.

Plate Wheels, are wheels without arms.

A **Rack**, is a series of teeth set in a plane.

A **Sector**, is a wheel which reciprocates without forming a full revolution.

A **Spur Wheel**, is a wheel having its teeth perpendicular to its axis.

A **Bevel Wheel**, is a wheel having its teeth at an angle with its axis.

A **Crown Wheel**, is a wheel having its teeth at a right angle with its axis.

A **Mitre Wheel**, is a wheel having its teeth at an angle of 45° with its axis.

A **Face Wheel**, is a wheel having its teeth set upon one of its sides.

An **Annular** or *Internal Wheel*, is a wheel having its teeth convergent to its centre.

Spur Gear. — Wheels which act upon each other in the same plane.

Bevel Gear. — Wheels which act upon each other at an angle.

When the tooth of a wheel is made of a material different from

that of the wheel, it is termed a **Cog**; in a pinion it is termed a **Leaf**, and in a trundle a **Stave.**

A wheel which impels another is termed the **Spur**, **Driver**, or **Leader**; the one impelled is the **Pinion**, **Driven**, or **Follower.**

A series of wheels in connection with each other is termed a **Train.**

When two wheels act upon one another, the greater is termed the **Wheel** and the lesser the **Pinion.**

A **Trundle**, **Lantern**, or **Wallower** is when the teeth of a pinion are constructed of round brass or solid cylinders set into two discs.

A **Trundle** with less than eight staves cannot be operated uniformly by a wheel with any number of teeth.

The material of which cogs are made is about one-fourth the strength of cast iron. The product of their $b\,d^2$ should be four times that of iron teeth.

Buchanan: Rules that to increase or diminish velocity in a given proportion, and with the least quantity of wheel-work, the number of teeth in each pinion should be to the number of teeth in its wheel as 1 : 3·59. Even to save space and expense, the ratio should never exceed 1 : 6.

The least number of teeth that it is practicable to give to a wheel is regulated by the necessity of having at least one pair always in action, in order to provide for the contingency of a tooth breaking.

The teeth of wheels should be as small and numerous as is consistent with strength.

When a **Pinion is driven by a wheel**, the number of teeth in the pinion should not be less than eight.

When a **Wheel is driven by a pinion**, the number of teeth in the pinion should not be less than ten.

The **Number of teeth** in a wheel should always be prime to the number of the pinion; that is, the number of teeth in the wheel should not be divisible by the number of teeth in the pinion without a remainder. This is in order to prevent the same teeth coming together so often as to cause an irregular wear of their faces. An odd tooth introduced into a wheel is termed a *hunting tooth* or *cog*.

To Compute the Pitch of a Wheel.

Rule. — Divide circumference at the pitch-line by the number of teeth.

Example. — A wheel 40 ins. in diameter requires 75 teeth; what is its pitch?

$$\frac{3{\cdot}1416 \times 40}{75} = 1{\cdot}6755 \textit{ ins.}$$

To Compute the True or Chordial Pitch.

Rule. — Divide 180° by the number of teeth, ascertain the sine of the quotient and multiply it by the diameter of the wheel.

Example.—The number of teeth is 75, and the diameter 40 inches; what is the true pitch?

$$\frac{180}{75} = 2^\circ\ 24' \text{ and } sin. \text{ of } 2^\circ\ 24' = \cdot 04188, \text{ which} \times 40 = 1\cdot 6752 \textit{ ins.}$$

To Compute the Diameter of a Wheel.

RULE.—Multiply the number of teeth by the pitch, and divide the product by 3·1416.

Example.—The number of teeth in a wheel is 75, and the pitch 1·675 ins.; what is the diameter of it?

$$\frac{75 \times 1\cdot 6755}{3\cdot 1416} = 10 \textit{ ins.}$$

To Compute the Number of Teeth in a Wheel.

RULE.—Divide the circumference by the pitch.

To Compute the Diameter when the True Pitch is given.

RULE.—Multiply the number of teeth in the wheel by the true pitch, and again by ·3184.

Example.—Take the elements of the preceding case.

$$75 \times 1\cdot 6752 \times \cdot 3184 = 40 \textit{ ins.}$$

To Compute the Number of Teeth in a Pinion or Follower to have a given Velocity.

RULE.—Multiply the velocity of the driver by its number of teeth, and divide the product by the velocity of the driven.

Example.—The velocity of a driver is 16 revolutions, the number of its teeth 54, and the velocity of the pinion is 48; what is the number of its teeth?

$$\frac{16 \times 54}{48} = 18 \textit{ teeth.}$$

2. A wheel having 75 teeth is making 16 revolutions per minute; what is the number of teeth required in the pinion to make 24 revolutions in the same time?

$$\frac{16 \times 75}{24} = 50 \textit{ teeth.}$$

To Compute the Proportional Radius of a Wheel or Pinion.

RULE.—Multiply the length of the line of centres by the number of teeth in the wheel for the wheel, and in the pinion for the pinion, and divide by the number of teeth in both the wheel and pinion.

To Compute the Diameter of a Pinion, when the Diameter of the Wheel and Number of Teeth in the Wheel and Pinion are given.

RULE.—Multiply the diameter of the wheel by the number of teeth in the pinion, and divide the product by the number of teeth in the wheel.

Example.—The diameter of a wheel is 25 inches, the number of its teeth 210, and the number of teeth in the pinion 30; what is the diameter of the pinion?

$$\frac{25 \times 30}{210} = 3{\cdot}57 \textit{ inches.}$$

To Compute the Number of Teeth required in a Train of Wheels to produce a given Velocity.

RULE.—Multiply the number of teeth in the driver by its number of revolutions, and divide the product by the number of revolutions of each pinion, for each driver and pinion.

Example.—If a driver in a train of three wheels has 90 teeth, and makes 2 revolutions, and the velocities required are 2, 10, and 18, what are the number of teeth in each of the other two?

$$10 : 90 :: 2 : 18 = \textit{teeth in 2d wheel.}$$
$$18 : 90 :: 2 : 10 = \textit{teeth in 3d wheel.}$$

To Compute the Circumference of a Wheel.

RULE.—Multiply the number of teeth by their pitch.

To Compute the Revolutions of a Wheel or Pinion.

RULE.—Multiply the diameter or circumference of the wheel or the number of its teeth, as the case may be, by the number of its revolutions, and divide the product by the diameter, circumference, or number of teeth in the pinion.

Example.—A pinion 10 inches in diameter is driven by a wheel 2 feet in diameter, making 46 revolutions per minute; what is the number of revolutions of the pinion?

$$\frac{2 \times 12 \times 46}{10} = 110{\cdot}4 \textit{ revolutions.}$$

To Compute the Velocity of a Pinion.

RULE.—Divide the diameter, circumference, or number of teeth in the driver, as the case may be, by the diameter, etc., of the pinion.

When there are a Series or Train of Wheels and Pinions.

RULE. — Divide the continued product of the diameter, circumference, or number of teeth in the wheels by the continued product of the diameter, etc., of the pinions.

Example 1.—If a wheel of 32 teeth drive a pinion of 10, upon the axis of which there is one of 30 teeth, driving a pinion of 8, what are the revolutions of the last?

$$\frac{32}{10} \times \frac{30}{8} = \frac{960}{80} = 12 \textit{ revolutions.}$$

Example 2.—The diameters of a train of wheels are 6, 9, 9, 10, and 12 inches; of the pinions, 6, 6, 6, 6, and 6 inches; and the number of revolutions of the driving shaft or prime mover is 10; what are the revolutions of the last pinion?

$$\frac{6 \times 9 \times 9 \times 10 \times 12 \times 10}{6 \times 6 \times 6 \times 6 \times 6} = \frac{583200}{7776} = 75 \textit{ revolutions.}$$

To Compute the Proportion that the Velocities of the Wheels in a Train should bear to one another.

RULE.—Subtract the less velocity from the greater, and divide the remainder by one less than the number of wheels in the train; the quotient is the number, rising in arithmetical progression from the less to the greater velocity.

Example.—What should be the velocities of 3 wheels to produce 18 revolutions, the driver making 3?

$$\frac{18 - 3 = 15}{3 - 1 = 2} = 7{\cdot}5 = \textit{number to be added to velocity of the driver}$$

$= 7{\cdot}5 + 3 = 10{\cdot}5$, and $10{\cdot}5 + 7{\cdot}5 = 18$ *revolutions.* Hence 3, 10·5, and 18 *are the velocities of the three wheels.*

General Illustrations.

1. A wheel 96 inches in diameter, having 42 revolutions per minute, is to drive a shaft 75 revolutions per minute; what should be the diameter of the pinion?

$$\frac{96 \times 42}{75} = 53{\cdot}76 \textit{ inches.}$$

2. If a pinion is to make 20 revolutions per minute, required the diameter of another to make 58 revolutions in the same time.

$58 \div 20 = 2{\cdot}9 =$ *the ratio of their diameters.* Hence, if one to make 20 revolutions is given a diameter of 30 inches, the other will be $30 \div 2{\cdot}9 = 10{\cdot}345$ *inches.*

3. Required the diameter of a pinion to make 12½ revolutions in the same time as one of 32 inches diameter making 26.

$$\frac{32 \times 26}{12{\cdot}5} = 66{\cdot}56 \textit{ inches.}$$

4. A shaft, having 22 revolutions per minute, is to drive another shaft at the rate of 15, the distance between the two shafts upon the line of centres is 45 inches; what should be the diameter of the wheels?

Then, 1st. $22 + 15 : 22 :: 45 : 26{\cdot}75 =$ *inches in the radius of the pinion.*

2d. $22 + 15 : 15 :: 45 : 18{\cdot}24 =$ *inches in the radius of the spur.*

5. A driving shaft, having 16 revolutions per minute, is to drive a shaft 81 revolutions per minute, the motion to be communicated by two geared wheels and two pulleys, with an intermediate shaft; the driving wheel is to contain 54 teeth, and the driving pulley upon the driven shaft is to be 25 inches in diameter; required the number of teeth in the driven wheel, and the diameter of the driven pulley.

Let the driven wheel have a velocity of $\sqrt{16 \times 81} = 36$, a mean proportional between the extreme velocities 16 and 81.

Then, 1st. $36 : 16 :: 54 : 24 =$ *teeth in the driven wheel.*

2d. $81 : 36 :: 25 : 11{\cdot}11 =$ *inches diameter of the driven pulley.*

6. If, as in the preceding case, the whole number of revolutions of the driving shaft, the number of teeth in its wheel, and the diameters of the pulleys are given, what are the revolutions of the shafts?

Then, 1st. $18 : 16 :: 54 : 48 =$ *revolutions of the intermediate shaft.*

2d. $15 : 48 :: 25 : 80 =$ *revolutions of the driven shaft.*

To Compute the Diameter of a Wheel for a given Pitch and Number of Teeth.

Rule. — Multiply the diameter in the following table for the number of teeth by the pitch, and the product will give the diameter at the pitch circle.

Example.—What is the diameter of a wheel to contain 48 teeth of 2·5 inches pitch?

$$15{\cdot}29 \times 2{\cdot}5 = 38{\cdot}225 \textit{ inches.}$$

To Compute the Pitch of a Wheel for a given Diameter and Number of Teeth.

Rule.—Divide the diameter of the wheel by the diameter in the table for the number of teeth, and the product will give the pitch.

Example.—What is the pitch of a wheel when the diameter of it is 50·94 inches, and the number of its teeth 80?

12

$$\frac{50{\cdot}94}{25{\cdot}47} = 2 \textit{ inches.}$$

PITCH OF WHEELS.

A TABLE WHEREBY TO COMPUTE THE DIAMETER OF A WHEEL FOR A GIVEN PITCH, OR THE PITCH FOR A GIVEN DIAMETER.

From 8 *to* 192 *teeth.*

No. of Teeth.	Diameter.	No. of Teeth.	Diameter.	No. of Teeth.	Diameter.	No. of Teeth.	Diameter.	No. of Teeth.	Diameter.
8	2·61	45	14·33	82	26·11	119	37·88	156	49·66
9	2·93	46	14·65	83	26·43	120	38·2	157	49·98
10	3·24	47	14·97	84	26·74	121	38·52	158	50·3
11	3·55	48	15·29	85	27·06	122	38·84	159	50·61
12	3·86	49	15·61	86	27·38	123	39·16	160	50·93
13	4·18	50	15·93	87	27·7	124	39·47	161	51·25
14	4·49	51	16·24	88	28·02	125	39·79	162	51·57
15	4·81	52	16·56	89	28·33	126	40·11	163	51·89
16	5·12	53	16·88	90	28·65	127	40·43	164	52·21
17	5·44	54	17·2	91	28·97	128	40·75	165	52·52
18	5·76	55	17·52	92	29·29	129	41·07	166	52·84
19	6·07	56	17·8	93	29·61	130	41·38	167	53·16
20	6·39	57	18·15	94	29·93	131	41·7	168	53·48
21	6·71	58	18·47	95	30·24	132	42·02	169	53·8
22	7·03	59	18·79	96	30·56	133	42·34	170	54·12
23	7·34	60	19·11	97	30·88	134	42·66	171	54·43
24	7·66	61	19·42	98	31·2	135	42·98	172	54·75
25	7·98	62	19·74	99	31·52	136	43·29	173	55·07
26	8·3	63	20·06	100	31·84	137	43·61	174	55·39
27	8·61	64	20·38	101	32·15	138	43·93	175	55·71
28	8·93	65	20·7	102	32·47	139	44·25	176	56·02
29	9·25	66	21·02	103	32·79	140	44·57	177	56·34
30	9·57	67	21·33	104	33·11	141	44·88	178	56·66
31	9·88	68	21·65	105	33·43	142	45·2	179	56·98
32	10·2	69	21·97	106	33·74	143	45·52	180	57·23
33	10·52	70	22·29	107	34·06	144	45·84	181	57·62
34	10·84	71	22·61	108	34·38	145	46·16	182	57·93
35	11·16	72	22·92	109	34·7	146	46·48	183	58·25
36	11·47	73	23·24	110	35·02	147	46·79	184	58·57
37	11·79	74	23·56	111	35·34	148	47·11	185	58·89
38	12·11	75	23·88	112	35·65	149	47·43	186	59·21
39	12·43	76	24·2	113	35·97	150	47·75	187	59·53
40	12·74	77	24·52	114	36·29	151	48·07	188	59·84
41	13·06	78	24·83	115	36·61	152	48·39	189	60·16
42	13·38	79	25·15	116	36·93	153	48·7	190	60·48
43	13·7	80	25.47	117	37·25	154	49·02	191	60·81
44	14·02	81	25·79	118	37·56	155	49·34	192	61·13

NOTE. — The pitch in this table is the true pitch, as before described.

To Compute the Number of Teeth of a Wheel for a given Diameter and Pitch.

RULE. — Divide the diameter by the pitch, and opposite to the quotient in the table is given the number of teeth. (See p. 154.)

Change Wheels in Screw-cutting Lathes.

$\frac{T\,S}{t\,t'}\,I = N$; $\frac{t\,t'}{I\,T} = S$. T *representing number of teeth in traverse screw;* S *number in stud-wheel gearing in mandril;* t *number in wheel upon mandril, and* t' *number in gearing upon stud pinion, gearing in* T; I *number of threads per inch upon traverse screw;* N *number to be cut.*

To determine the Proportion of Wheels for Screw-cutting by a Lathe.

In a lathe properly adapted, screws to any degree of pitch, or number of threads in a given length, may be cut by means of a leading screw of any given pitch, accompanied with change wheels and pinions; coarse pitches being effected generally by means of one wheel and one pinion with a *carrier*, or *intermediate wheel*, which cause no variation or change of motion to take place. Hence the following

RULE.— Divide the number of threads in a given length of the screw which is to be cut by the number of threads in the same length of the leading screw attached to the lathe; and the quotient is the ratio that the wheel on the end of the screw must bear to that on the end of the lathe spindle.

Example.— Let it be required to cut a screw with 5 threads in an inch, the leading screw being of $\frac{1}{2}$ inch pitch, or containing 2 threads in an inch; what must be the ratio of wheels applied?

$5 \div 2 = 2{\cdot}5$, the ratio they must bear to each other.

Then suppose a pinion of 40 teeth be fixed upon for the spindle.

$40 \times 2{\cdot}5 = 100$ teeth for the wheel on the end of the screw.

But screws of a greater degree of fineness than about 8 threads in an inch are more conveniently cut by an additional wheel and pinion, because of the proper degree of velocity being more effectively attained; and these, on account of revolving upon a stud, are commonly designated the *stud-wheels*, or *stud-wheel* and *pinion;* but the mode of calculation and ratio of screw are the same as in the preceding rule. Hence, all that is further necessary is to fix upon any three wheels at pleasure, as those for the spindle and stud-wheels; then multiply the number of teeth in the spindle-wheel by the ratio of the screw, and by the number of teeth in that wheel or pinion which is in contact with the wheel on the end of the screw; divide the product by the stud-wheel in contact with the spindle-wheel; and the quotient is the number of teeth required in the wheel on the end of the leading screw.

Example.— Suppose a screw is required to be cut containing 25

threads in an inch, and the leading screw, as before, having two threads in an inch, and that a wheel of 60 teeth is fixed upon for the end of the spindle, 20 for the pinion in contact with the screw-wheel, and 100 for that in contact with the wheel on the end of the spindle; required the number of teeth in the wheel for the end of the leading screw.

$$25 \div 2 = 12{\cdot}5, \text{ and } \frac{60 \times 12{\cdot}5 \times 20}{100} = 150 \text{ teeth.}$$

Or suppose the spindle and screw-wheels to be those fixed upon, also any one of the stud-wheels, to find the number of teeth in the other.

$$\frac{60 \times 12{\cdot}5}{150 \times 100} = 20 \text{ teeth, or } \frac{60 \times 12{\cdot}5 \times 20}{150} = 100 \text{ teeth.}$$

TABLE OF CHANGE WHEELS FOR SCREW-CUTTING.

The leading Screw being ½ inch pitch, or containing 2 threads in an inch.

Number of threads in inch of screw.	Number of teeth in		Number of threads in inch of screw.	Number of teeth in				Number of threads in inch of screw.	Number of teeth in			
	Lathe spindle-wheel.	Leading screw-wheel.		Lathe spindle-wheel.	Wheel in contact with spindle-wheel.	Pinion in contact with screw-wheel.	Leading screw-wheel.		Lathe spindle-wheel.	Wheel in contact with spindle-wheel.	Pinion in contact with screw-wheel.	Leading screw-wheel.
1	80	40	8¼	40	55	20	60	19	50	95	20	100
1¼	80	50	8½	90	85	20	90	19½	80	120	20	130
1½	80	60	8¾	60	70	20	75	20	60	100	20	120
1¾	80	70	9½	90	90	20	95	20¼	40	90	20	90
2	80	90	9¾	40	60	20	65	21	80	120	20	140
2¼	80	90	10	60	75	20	80	22	60	110	20	120
2½	80	100	10½	50	70	20	75	22½	80	120	20	150
2¾	80	110	11	60	55	20	120	22¾	80	130	20	140
3	80	120	12	90	90	20	120	23¾	40	95	20	100
3¼	80	130	12¾	60	85	20	90	24	65	120	20	130
3½	80	140	13	90	90	20	130	25	60	100	20	150
3¾	40	150	13½	60	90	20	90	25½	30	85	20	90
4	40	80	13¾	80	100	20	110	26	70	130	20	140
4¼	40	85	14	90	90	20	140	27	40	90	20	120
4½	40	90	14¼	60	90	20	95	27½	40	100	20	110
4¾	40	95	15	90	90	20	150	28	75	140	20	150
5	40	100	16	60	80	20	120	28½	30	90	20	95
5½	40	110	16¼	80	100	20	130	30	70	140	20	150
6	40	120	16½	80	110	20	120	32	30	80	20	120
6½	40	130	17	45	85	20	90	33	40	110	20	120
7	40	140	17½	80	100	20	140	34	30	85	20	120
7½	40	150	18	40	60	20	120	35	60	140	20	150
8	30	210	18¾	80	100	20	150	36	30	190	20	120

Example 1. — Required the number of teeth that a wheel of 16 inches diameter will contain of a 10 pitch.

$16 \times 10 = 160$ teeth, and the circular pitch $= \cdot 314$ inch.

Example 2. — What must be the diameter of a wheel for a 9 pitch of 126 teeth?

$126 \div 9 = 14$ inches diameter, circular pitch ·349 inch.

NOTE. — The pitch is reckoned on the diameter of the wheel instead of the circumference, and designated wheels of 8 pitch, 12 pitch, etc.

STRENGTH OF THE TEETH OF CAST IRON WHEELS AT A GIVEN VELOCITY.

Pitch of teeth in inches.	Thickness of teeth in inches.	Breadth of teeth in inches.	Strength of teeth in horse-power at 3 feet per second.	4 feet per second.	6 feet per second.	8 feet per second.
3·99	1·9	7·6	20·57	27·43	41·14	54·85
3·78	1·8	7·2	17·49	23·32	34·98	46·64
3·57	1·7	6·8	14·73	19·65	29·46	39·28
3·36	1·6	6·4	12·28	16·38	24·56	32·74
3·15	1·5	6·	10·12	13·50	20·24	26·98
2·94	1·4	5·6	8·22	10·97	16·44	21·92
2·73	1·3	5·2	6·58	8·78	13·16	17·54
2·52	1·2	4·8	5·18	6 91	10·36	13·81
2·31	1·1	4·4	3·99	5·32	7·98	10·64
2·1	1·0	4·	3·00	4·00	6·00	8·00
1·89	·9	3·6	2·18	2·91	4·36	5·81
1·68	·8	3·2	1·53	2·04	·06	3·08
1·47	·7	2·8	1·027	1·37	2·04	2 72
1.26	·6	2·4	·64	·86	1·38	1·84
1·05	·5	2·	·375	·50	·75	1·00

WHEELS AND GUDGEONS.

To find size of Teeth necessary to Transmit a given Horse Power. (Tredgold.)

$$\frac{\text{Horse power} \times 240}{\text{Diameter of wheel, ft.} \times \text{Revs. per min.}} = \text{Strength of tooth.}$$

$$\sqrt{\frac{\text{Strength}}{\text{Breadth, ins.}}} = \text{Pitch, ins.} \quad \frac{\text{Strength}}{(\text{Pitch, ins.})^2} = \text{Breadth, ins.}$$

The above rule will be found very suitable for a speed of circumference of about 240 feet per minute. For speeds above, add to 240 half the difference; for speeds below, deduct half the dif-

ference between 240 and the actual speed, the result being a suitable multiplier.

For instance: at 300 feet per minute, 60 being the difference, $240 + 30 = 270$ multiplier.

At 160 feet per minute, 80 being the difference, $240 - 40 = 200$ multiplier.

The reason being that, with higher speeds, the friction, wear, and liability to shocks is increased, at lower speeds decreased, and the teeth may advantageously be proportioned accordingly.

To find the Horse Power that any Wheel will Transmit.

$$\frac{(\text{Pitch, ins.})^2 \times \text{Breadth, ins.} \times \text{Diameter, ft.} \times \text{Revs. per minute}}{\text{Appropriate No. according to speed, as above}}$$
$= \text{Horse Power.}$

To find the Multiplying Number for any Wheel.

$$\frac{(\text{Pitch, ins.})^2 \times \text{Breadth, ins.} \times \text{Diameter, ft.} \times \text{Revs. per minute}}{\text{Horse Power}}$$
$= \text{Multiplying No. as above.}$

To find the Size of Teeth to carry a given Load in Pounds.

Load, lbs. $\div$ 1120 = Breaking strength of teeth.

Load, lbs. $\div$ 280 = Strength for very low speeds, and for steady work; being 4 times the breaking strength.

Load, lbs. $\div$ 140 = Strength for ordinary purposes of machinery; being 8 times the breaking strength.

Load, lbs. $\div$ 100 = Strength for high speeds and irregular work; or when the teeth are exposed to shocks.

As before,

$$\frac{\text{Strength}}{(\text{Pitch, ins.})^2} = \text{Breadth, ins.} \quad \sqrt{\frac{\text{Strength}}{\text{Breadth, ins.}}} = \text{Pitch, ins.}$$

WATER.

[See page 87.]

To find the Quantity of Water that will be Discharged through an Orifice or Pipe in the Side or Bottom of a Vessel.

Area of orifice, sq. in. × { No. corresponding to height of surface above orifice, as per table
= Cubic feet discharged per minute.

Height of Surface above Orifice.	Multiplier.	Height of Surface above Orifice.	Multiplier.	Height of Surface above Orifice.	Multiplier.
Feet.		Feet.		Feet.	
1	2·25	18	9·5	40	14·2
2	3·2	20	10·	45	15·1
4	4·5	22	10·5	50	16·
6	5·44	24	11·	60	17·4
8	6·4	26	11·5	70	18·8
10	7·1	28	12·	80	20·1
12	7·8	30	12·3	90	21·3
14	8·4	32	12·7	100	22·5
16	9·	35	13·3		

To find the Size of Hole necessary to Discharge a given Quantity of Water under a given Head.

$$\frac{\text{Cubic feet water discharged}}{\text{No. corresponding to height, as per table}} = \text{Area of orifice, sq. in.}$$

To find the Height necessary to Discharge a given Quantity through a given Orifice.

$$\frac{\text{Cubic feet water discharged}}{\text{Area orifice, sq. inches}} = \text{No. corresp. to height, as per table.}$$

The Velocity of Water issuing from an Orifice in the Side or Bottom of a Vessel being ascertained to be as follows:

$$\sqrt{\text{Height ft. surface above orifice}} \times 5{\cdot}4 = \left\{ \text{Velocity of water, ft. per second.} \right.$$

$$\sqrt{\text{Height ft.}} \times \text{Area orifice, ft.} \times 324 = \left\{ \text{Cubic feet discharged per minute.} \right.$$

$$\sqrt{\text{Height ft.}} \times \text{Area orifice, ins.} \times 2.2 = \quad \text{Do.} \quad \text{Do.}$$

It may be observed that the above rules represent the actual quantities that will be delivered through a hole cut in the plate: if a short pipe be attached, the quantity will be increased, the greatest delivery with a straight pipe being attained with a length equal to 4 diameters, and being $\frac{1}{3}$ more than the delivery through the plain hole; the quantity gradually decreasing as the length of pipe is increased, till, with a length equal to 60 diameters, the discharge again equals the discharge through the plain orifice. If a taper pipe be attached, the delivery will be still greater, being $1\frac{1}{2}$ times the delivery through the plain orifice; and it is probable that if a pipe with curved decreasing taper were to be tried, the delivery through it would be equal to the theoretical discharge, which is about 1.65 the actual discharge through a plain hole.

To find the Quantity of Water that will run through any Orifice, the top of which is level with the Surface of Water as over a Sluice or Dam.

$$\sqrt{\left.\begin{matrix}\text{Height, ft. from water surface to}\\ \text{bottom of orifice or top of dam}\end{matrix}\right\}} \times \left.\begin{matrix}\text{Area of water}\\ \text{passage, sq.ft.}\end{matrix}\right\} \times 256$$

= Cubic feet discharged per minute.

Or,

Two-thirds area of water passage, sq. ins. × No. corresponding to height as per table = Cubic feet discharged per minute.

To find the time in which a Vessel will empty itself through a given Orifice.

$$\frac{\sqrt{\text{Height, feet surface above orifice}} \times \text{Area water surface, sq. ins.}}{\text{Area orifice, square inch} \times 3{\cdot}7}$$

= Time required, seconds.

The above rules are founded on Bank's experiments.

GAUGING OF CASKS.

In taking the dimensions of a Cask, it must be carefully observed: 1st, That the bung-hole be in the middle of the cask; 2d, That the bung-stave, and the stave opposite to the bung-hole, are both regular and even within; 3d, That the heads of the Cask are equal, and truly circular; if so, the distance between the inside of the chime to the outside of the opposite stave will be the head diameter within the cask, very near.

Rule. — Take, in inches, the *inside* diameters of a cask at the head and the bung, and also the length; subtract the head-diameter from the bung-diameter, and note the difference.

If the measure of the Cask is taken outside, with callipers, from head to head, then a deduction must be made of from 1 to 2 inches for the thickness of the heads, according to the size of the Cask.

1. *If the staves of the Cask, between the bung and the head, are considerably curved,* (the shape of a pipe,) multiply the difference between the bung and head by ·7.

2. *If the staves be of a medium curve,* (the shape of a molasses hogshead,) multiply the difference by ·65.

3. *If the staves curve very little,* (less than a molasses hogshead,) multiply the difference by ·6.

4. *If the staves are nearly straight,* (almost a cylinder,) multiply the difference by ·55.

5. Add the product, in each case, to the head-diameter; the sum will be a mean diameter, and thus the Cask is reduced to a cylinder.

6. Multiply the *mean* diameter by itself, and then by the length, and multiply, if for Wine gallons, by ·0034. The difference of dividing by 294, (the usual method,) and multiplying by ·0034, (the most expeditious method,) is less than 500ths of a gallon in 100 gallons.

Example. — Supposing the head-diameter of a Cask to be 24 inches, the bung-diameter 32 inches, and the length of Cask 40 inches, what is the contents in Wine gallons?

First variety.

Bung-Diameter,	32	Brought up,	876·16
Head-Diameter,	24	Length,	40
Difference,	8		35046·40
Multiplier,	·7		·0034
	5·6		14018560
Head-Diam.,	24		10513920
	29·6		119·157760
Multiply by	29·6		
[Carry up] Square,	876·16	*Ans.*	119 galls. 1 pint.

To obtain the contents of a similar Cask in Ale gallons, multiply 35046·40 by ·002785, and we get 97·6042, (or 97 gallons 5 pints.)

Gauging of Casks in Imperial (British) Gallons, and also in United States Gallons.

Having ascertained the *variety* of the Cask, and its *interior* dimensions, the following Table will facilitate the calculation of its capacity.

TABLE OF THE CAPACITIES OF CASKS, WHOSE BUNG DIAMETERS AND LENGTHS ARE 1 OR UNITY.

H.	1st Var.	2d Var.	3d Var.	4th Var.	H.	1st Var.	2d Var.	3d Var.	4th Var.
·50	·0021244	·0020300	·0017704	·0016523	·76	·0024337	·0024120	·0022343	·0022071
·51	·0021340	·0020433	·0017847	·0016713	·77	·0024482	·0024282	·0022560	·0022310
·52	·0021437	·0020567	·0017993	·0016905	·78	·0024628	·0024445	·0022780	·0022551
·53	·0021536	·0020702	·0018141	·0017098	·79	·0024777	·0024610	·0023002	0022794
·54	·0021637	·0020838	·0018293	·0017294	·80	·0024927	·0024776	·0023227	·0023038
·55	·0021740	·0020975	·0018447	·0017491	·81	·0025079	·0024942	·0023455	·0023285
·56	·0021845	·0021114	·0018604	·0017690	·82	·0025233	·0025110	·0023686	·0023533
·57	·0021951	·0021253	·0018764	·0017891	·83	·0025388	·0025279	·0023920	·0023783
·58	·0022060	·0021394	·0018927	·0018094	·84	·0025546	·0025449	·0024156	·0024035
·59	·0022170	·0021536	·0019093	·0018299	·85	·0025706	·0025621	·0024396	·0024289
·60	·0022283	·0021679	·0019261	·0018506	·86	·0025867	·0025793	·0024638	·0024545
·61	·0022397	·0021823	·0019433	·0018715	·87	·0026030	·0025967	·0024883	·0024803
·62	·0022513	·0021968	·0019607	·0018925	·88	·0026196	·0026141	·0025131	·0025063
·63	·0022631	·0022114	·0019784	·0019138	·89	·0026363	·0026317	·0025381	·0025324
·64	·0022751	·0022262	·0019964	·0019352	·90	·0026532	·0026494	·0025635	·0025588
·65	·0022873	·0022410	·0020147	·0019568	·91	·0026703	·0026672	·0025891	0025853
·66	·0022997	·0022560	·0020332	·0019786	·92	·0026875	·0026851	·0026150	0026120
·67	·0023122	·0022711	·0020521	·0020006	·93	·0027050	·0027032	·0026412	·0026389
·68	·0023250	·0022863	·0020712	·0020228	·94	·0027227	·0027213	·0026677	·0026660
·69	·0023379	·0023016	·0020906	·0020452	·95	·0027405	·0027396	·0026945	·0026933
·70	·0023510	·0023170	·0021103	·0020678	·96	·0027585	·0027579	·0027215	·0027208
·71	·0023643	·0023326	·0021302	·0020905	·97	·0027768	·0027764	·0027489	·0027484
·72	·0023778	·0023482	·0021505	·0021135	·98	·0027952	·0027950	·0027765	·0027763
·73	·0023915	·0023640	·0021710	·0021366	·99	·0028138	·0028137	·0028044	·0028043
·74	·0024054	·0023799	·0021918	·0021599	1·00	·0028326	·0028326	·0028326	·0028326
·75	·0024195	·0023959	·0022129	·0021834					

Divide the head by the bung diameter, and opposite the quotient in the column H, and under its proper variety, is the tabular number for unity. Multiply the tabular number by the square of the bung diameter of the given cask, and by its length, the product equals its capacity in Imperial gallons.

Required the number of gallons in a Cask, (*1st variety*,) 24 inches head-diameter, 32 bung-diameter, and 40 inches in length?

32) 24·0 (·75 see Table for tabular No.
·0024195 tabular No. for unity.
32 × 32 is 1024 square of bung diam.

96780
48390
24195

2·4775680
40 Inches long.

99·1027200 Imperial gallons.
1·2

1982054400
991027200

118·92326400 United States gallons.

NOTE. — Multiplying Imperial gallons by one and two-tenths (1·2) will convert them into U. S. gallons; and U. S. gallons multiplied by ·833 equal Imperial gallons.

To Ullage, or find the Contents in Gallons of a Cask partly filled.

To find the contents of the occupied part of a lying cask in gallons.

RULE.— Divide the depth of the liquid, or wet inches, by the bung-diameter, and if the quotient is under ·5, deduct from the quotient *one-fourth* of what it is less than ·5, and multiply the remainder by the whole capacity of the cask; this product will be the number of gallons in the cask. But if the quotient exceeds ·5, add *one-fourth* of that excess to the quotient, and multiply the sum by the whole capacity of the cask; this product will be the number of gallons.

Example 1. — Suppose the bung-diameter of a cask, on its bilge, is 32 inches, and the whole contents of the cask 118·80 U. S. standard gallons; required the ullage of 15 wet inches.

32) 15.00 (·46875 ·5 — ·46875 = ·03125 ÷ 4 = ·0078125 ·46875 — ·0078125 = ·4609375 × 118·80 = 54·759375 U. S. gallons.

Example 2.— Required the ullage of 17 wet inches in a cask of the above capacity.

32)17·00(·53125 — ·5 = ·03125 ÷ 4 = ·0078125 + ·53125 = ·5390625 × 118·80 = 64·040625 U. S. gallons.

PROOF.— 64·040625 + 54·759375 = 118·80 *gallons.*

To find the ullage of a filled part of a standing Cask, in gallons.

RULE.— Divide the depth of the liquid, or wet inches, by the length of the cask; then, if the quotient is less than ·5, deduct from the quotient *one-tenth* of what it is less than ·5, and multiply the remainder by the whole capacity of the cask; this product will be the number of gallons. But if the quotient exceeds ·5, add *one-tenth* of that excess to the quotient, and multiply the sum by the whole capacity of the cask; this product will be the ullage, or contents in U. S. standard gallons.

Example.— Suppose a cask, 40 inches in length, and the capacity 118·80 gallons, as above: required the ullage of 21 wet inches.

40) 21·000 (·525 — .5 = ·025 ÷ 10 = ·0025 + ·525 = ·5275 × 118·80 = 62·667 U. S. gallons.

NOTE.—Formerly the British Wine and Ale gallon measures were similar to those now used in the United States and British Colonies.

The following Tables exhibit the comparative value between the United States and the present British measures.

U. S. measure for wine, spirits, etc.	British (Im.) measure. galls.	qts.	pts.	gills.
42 galls. = 1 tierce, =	34	3	1	3
63 " = 1 hogsh. =	52	1	1	3
126 " = 1 pipe, =	104	3	1	3
252 " = 1 tun, =	209	3	1	2

U. S. measure for ale and beer.	British (Im.) measure. galls.	qts.	pts.	gills.
9 galls. = 1 firkin, =	9	0	1	1
36 " = 1 barrel, =	36	2	0	3
54 " = 1 hogsh. =	54	3	0	1
108 " = 1 butt, =	109	3	1	3

To convert Imperial gallons into United States Wine gallons, multiply the imperial by 1·2. To convert U. S. gallons into Imperial, multiply the U. States Wine gallons by ·833.

51 U. S. Ale gallons equal 60 Imperial gallons, therefore to convert one into other add or deduct $\frac{1}{60}$th.

ALLOYS AND COMPOSITIONS.

ALLOY is the proportion of a baser metal mixed with a finer or purer, as when copper is mixed with gold, &c.

AMALGAM is a compound of mercury and a metal — a soft alloy.

All compositions of copper contract in the admixture, and all amalgams expand.

In the manufacture of alloys and compositions, the more infusible metals should be melted first.

In compositions of brass, as the proportion of zinc is increased, so is the malleability decreased.

The tenacity of brass is impaired by the addition of lead or tin.

Steel alloyed with $\frac{5}{100}$th part of platinum, or silver, is rendered harder, more malleable, and better adapted for cutting instruments.

Any alloy which is slowly heated and gradually cooled (annealed, that is), is softer than when the compound is suddenly chilled; hence the hardness of chill-cast iron.

In moulding. no casting of any kind should be removed until it is cooled down to within a few degrees of the atmosphere; and in open sand castings, a thick covering of sand should be applied to retain the heat.

Neglect of this caution is certain to weaken the piece, and frequently is the cause of accidents.

ALLOYS AND COMPOSITIONS.

	Copper.	Zinc.	Tin.	Nickel.	Lead.	Antimony	Bismuth.	Silver	Cobalt of Iron.	Iron.	Arsenic.
Argentan	55.	24.		21.							
Argentiferous	50.	2.5	2.5	40.	2.5					2.5	...z
Babbitt's metal*	3.7		89.			7.3					
Brass, common	84.3	5 2	10.5								
" "	75.	25.									
" " hard	79.3	6.4	14.3								
" Mathematical instruments.	92.2		7.8								
" pinchbeck	80.	20.									
" red tombac	88.8	11.2									
" rolled	74.3	22.3	3.4								
" tutenag	50.	31.		19.							
" very tenacious	88.9	2.8	8.3								
" wheels, valves	90.		10.								
" white	10.	80.	10								
" wire	67.	33.									
" yellow, fine	66.	34.									
Britannia metal			25.			25.					
When fused, add						25.	25.				
Bronze, red	87.	13.									
" red	86.	11 1	2.9								
" yellow	67.2	31 2	1.6								
" Cymbals	80.		20.								
" gun metal, large	90.		10.								
" " small	93.		7.								
" Medals	93.		7.								
" Statuary	91.4	5.5	1.4		1.7						
Chinese Silver	65.1	19 3		13.				2.48	.12		
Chinese white copper	40.4	25.4	2.6	31.6							
Church bells	80.	5.6	10.1		4.3						
"	69.		31.								
Clock bells	72.		26.5							1.5	
Cocks, Musical bells	87.5		12.5								
German silver	33.3	33.4		33,3							
" "	40.4	25.4		31.6						2.6	
" " fine	49.5	24.		24.						2.5	
Gongs	81.6		18.4								
House bells	77.		23.								
Lathe bushes	80.		20.								
Machinery bearings	87.5		12.5								
" " hard	77.4	7.	15.6								
Metal that expands in cooling					75.	16.7	8.3				
Muntz metal	60.	40.									
Pewter, best			86.			14.					
"			80.		20.						
Printing characters					80.	20.					
Sheathing metal	56.	45.									
Speculum "	66.		22.								12.
" "	50.	21.	29.								
Telescopic mirrors	66.6		33.4								
Temper†	33.4		66.6								
Type and stereotype plates					69.	15.5	15.5				
White metal	7.4	7.4	28.4			56.8					
" " hard	69.8	25.8	4.4								
Oreide	73.	12.3	Magnesia 4.4 Cr'm of tartar 6.5; Sal-ammoniac 2.5 Quick-lime 1.33								

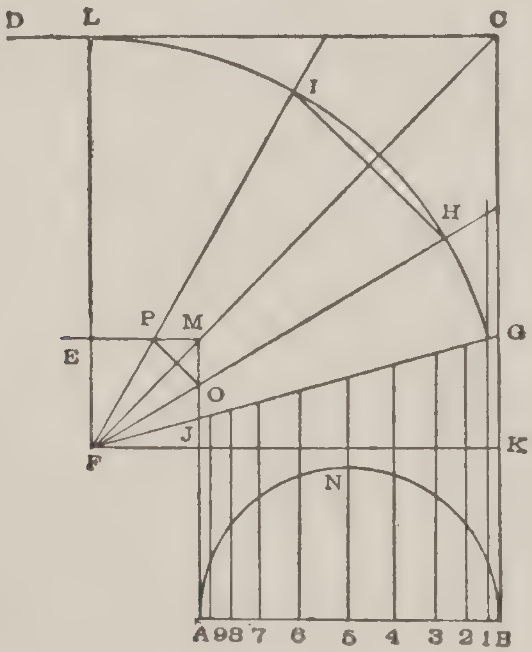
*See page 164 for directions. †For adding small quantities of copper.

ADDENDA TO PART I.

EXPLANATION OF DIAGRAMS FOR SHEET-METAL WORK, ETC.

To Describe a Pattern for a Four-piece Elbow.—Let A B E D, Fig. 45, be the given elbow; draw the line F C; make F M equal in length to one-half the diameter of the elbow with F as a centre; describe the arc K L; divide the arc K L into three equal parts; draw

Fig. 45.

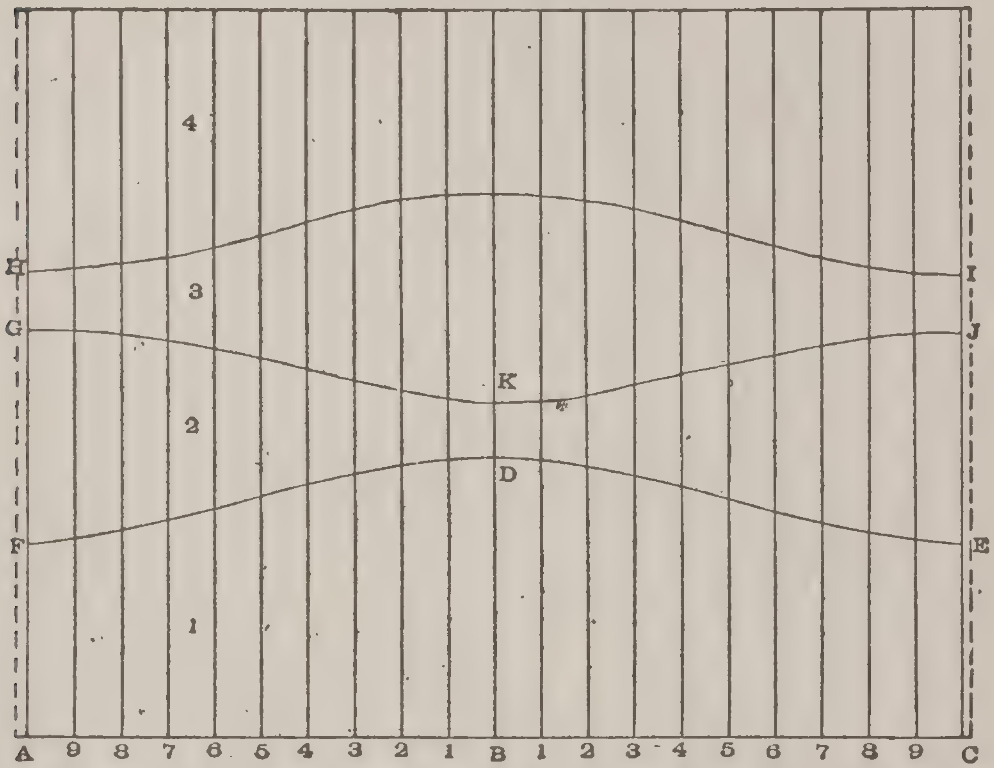


the lines F H and F I; also the line I H; divide the section H K into two equal parts, and draw the line F G; draw the line A B at right angles to B C; describe the semi-circle A N B; divide the semi-circle into any number of equal parts; from the points draw lines parallel to B C as 1, 2, 3, etc.

Set off the line A B C, Fig. 46, equal in length to the circumference of elbow A B; erect the lines A F, B D and C E; set off on each side of the line B D the same number of equal distances as in the semi-circle A N B; from the points draw lines parallel to B D, as 1, 1, 2, 2, etc.; make B D equal to B G; make A F and C E equal to A J; also

each of the parallel lines bearing the same number as 1, 1, 2, 2, 3, 3, etc.; then a line traced through the points will form the first section; make F G and E J equal to H I; reverse section No. 1; place E at G

Fig. 46.

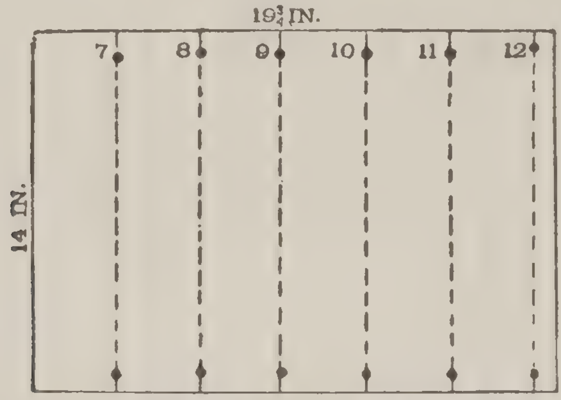


and F at J; trace a line from G to J; make G H and J I equal to P O, Fig. 45, or D K, Fig. 46; take section No. 1, place F at H and E at I, and trace a line from H to I; this forms sections No. 3 and 4. Edges to be allowed.

Round Furnace Pipe.—It is most convenient to make the joints 14 inches long, as the pipe is so much more convenient to handle, and if each joint is beaded 2 inches from the end, then it will measure just 1 foot when the pipe is put together. This makes easy figuring, as all one has to do is to take out as many joints as there are feet of pipe required, or the bead can be put nearer the small end, which will make the pipe longer, and perhaps save putting on a short piece in order to get the desired length. Some furnacemen square the tin for round pipe; that is, cut off the sides of the tin as well as the ends. This is not a good plan when the tin is kept on hand, as the cut edges are apt to rust, which makes it more difficult to solder the joints. A better way of making the pipe is to cut the sheets 19¾ inches long and then put in gores to make the desired size. By using this method the sheets can be made into any size of pipe required. An inspection of the engraving will show one how the gores are cut out of the sheet. For the 7-inch pipe six gores can be cut out of one sheet, but as the gore is so narrow, pieces can often be used. For 8-inch pipe three gores come out of a sheet, while the 9-inch takes about half of a sheet. Only one 10-inch gore can be taken out of a sheet, but the piece left will do for 8-inch or perhaps two can be grooved together and make a gore for the 10-inch. The 11-inch gore leaves a piece for 7-inch. When mak-

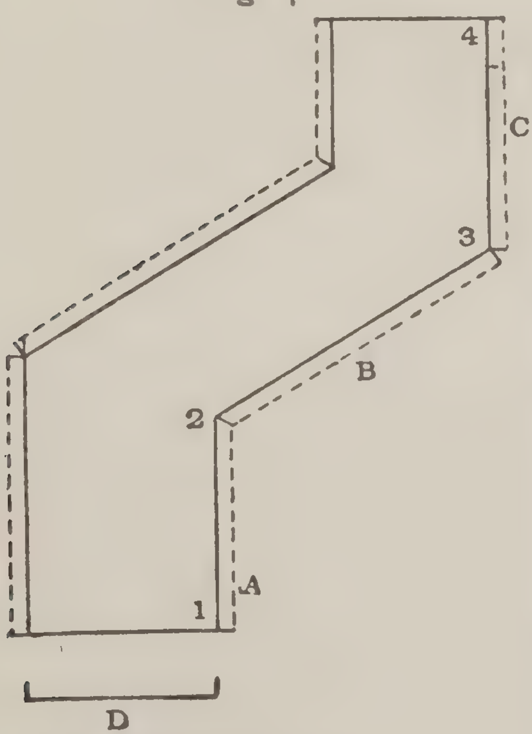
ing 12-inch pipe it might be well to have the pattern so that two pieces will make a joint, as the "gore" is so near the length of a sheet that a mistake might be made and get two sheets together. When cutting out the gores they can be made slightly tapering if required, so one

Fig. 47.



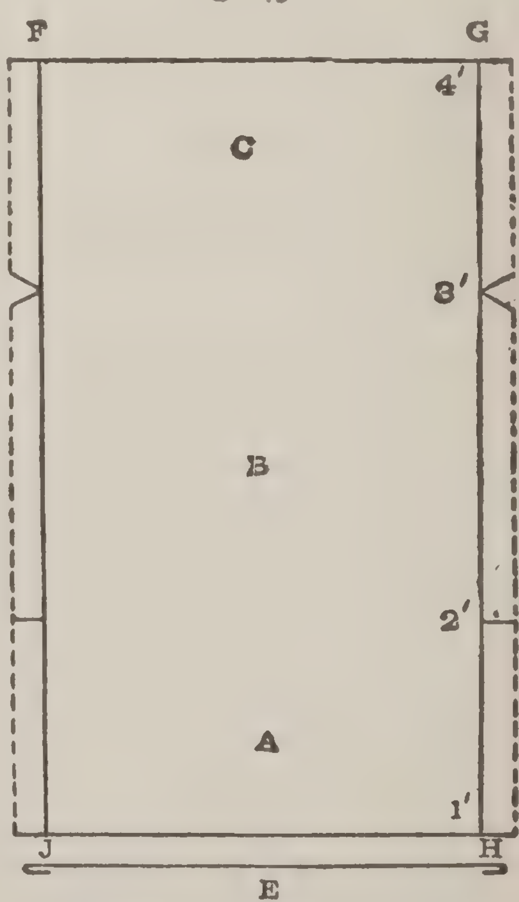
joint will slip into another, but if a combined crimper and beader is used, this is not necessary. When grooving the pipe together care should be had to have the pieces at the small end even, then there will be no difficulty in beading.

Fig. 48.



Side view of pipe.

Fig. 49.

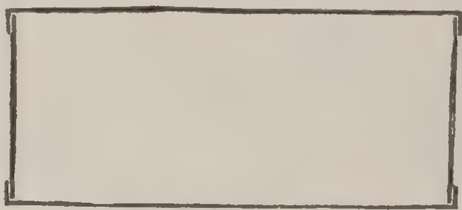


Pattern for back of pipe.

Crooked Furnace Pipe.—When putting square furnace pipes

in a house one frequently encounters places where curious-shaped pipes are required. A method recommended for most cases is to mark out on a piece of tin the side view of the pipe or bend to be made, as has been done in Fig. 48, the solid lines representing the desired shape, two pieces of which are required for the article. Allowance is then made for a single edge, as shown by the dotted lines, and the end view of the piece at D, which shows the edges turned up for double seaming. In Fig. 49 is shown the pattern for the back of the pipe. The width of pipe is shown by the solid lines F J and G H. To get the length of tin for A in Fig. 48, the distance from 1 to 2 is marked on the lines G H and F J as shown on pattern, then the distances from 2 to 3 and 3

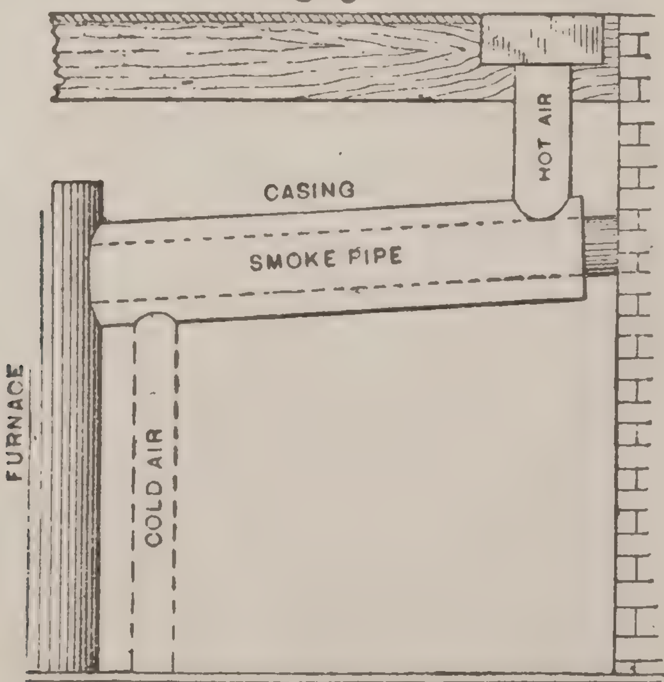
Fig. 50.



End view of pipe.

to 4 are marked in a similar manner as shown on pattern. As this piece is to be double seamed over on to Fig. 48, a double edge is allowed and formed, as shown at E in Fig. 49. The piece for the front of pipe is obtained in a similar manner. In Fig. 50 is shown an end view of the pipe, showing double seams on sides of pipe. It is not to be expected that this method of making the various shapes used in square pipes will be followed in all cases, for there is no one rule to be followed in making partition-pipes, but the idea intended to be conveyed is that when a strange-shaped pipe is to be made, the furnaceman has taken one good step in advance after the side view has been marked out, as it is a simple affair to get the length of tin for the front and back.

Fig. 51.

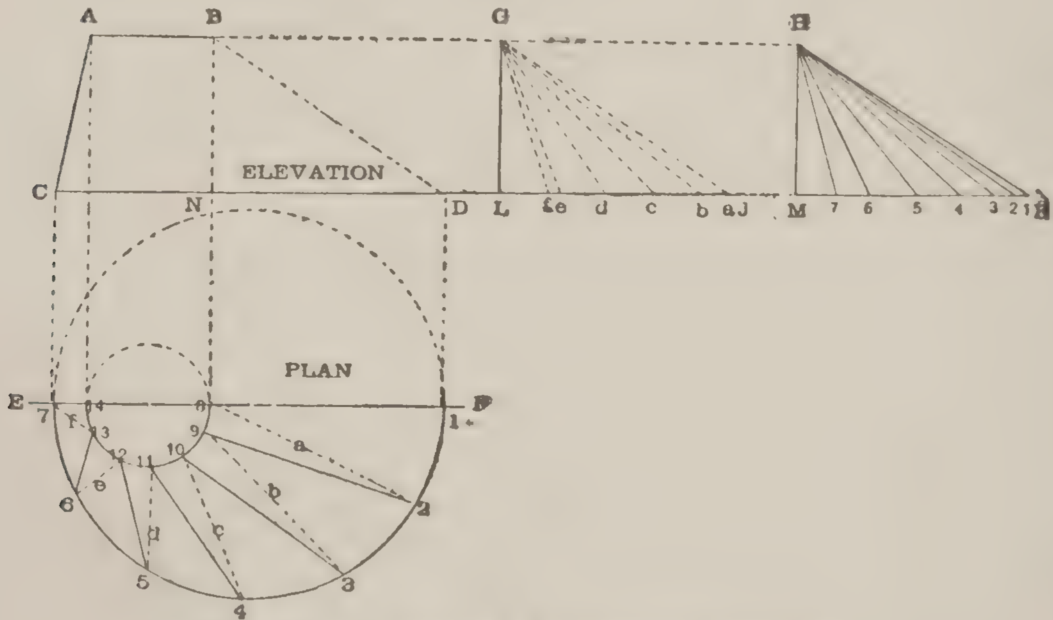


Encasing a Smoke-pipe.—Some furnaces are so situated that a

long smoke-pipe is necessary, and it may be that more heat escapes into the cellar than is wanted, especially if the cellar is used for storing fruit and vegetables. In order to remedy this difficulty, it is a good plan to encase the smoke-pipe with a pipe that may be from 4 to 6 in. larger than the smoke-pipe. Cold air can be admitted to the space between the casing and the smoke-pipe by a separate pipe, this pipe being connected with the cold-air box or the outer air, as desired. The other end of the casing can be tapered and the air taken to the room above by means of a pipe and register, as shown in the illustration, Fig. 51. While, by having a jacket or casing about the smoke-pipe, as shown, a great deal of heat may be taken from the smoke by the air passing up through the casing to the room above, the draft of the furnace is not injured to a perceptible extent, as the casing keeps the smoke-pipe surrounded by warm air. It is not intended that the supply or cold-air pipe is to be so large as to give more cold air than the smoke-pipe will heat, and to prevent this it would be well to put in a damper, so the supply could be regulated at will.

Pattern for Top of Milk-can—Triangulation in Pattern-cutting Explained.—The method employed in this case, as in others of a similar nature, is that of triangulation, as by this system the pattern for almost any irregular shape can be described. Referring to the engraving, Fig. 52, A B C D shows the elevation of can top for which the pattern is required, below which is drawn the plan divided into two equal portions by the line E F. In order to obtain the base of trian-

Fig. 52.



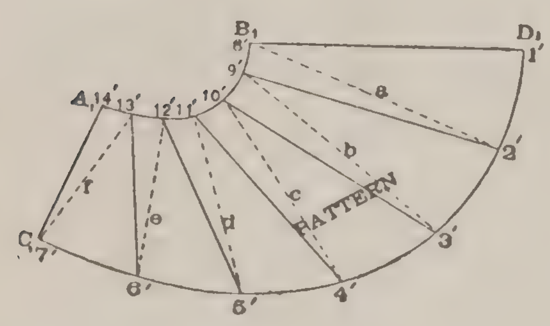
Elevation, plan and diagrams of triangles.

gles used in describing the pattern, the outer and inner half-circles on line E F are divided into the same number of equal parts, in the present instance six, and the points numbered 1 to 7 on the outer half-circle, and form 8 to 14 on the inner. Lines are now drawn from 2 to 9, 3 to 10, etc., which gives the length of base of triangles represented by solid lines, and lines drawn from 2 to 8, 3 to 9, etc., give the length of base of triangle represented by dotted lines and lettered from *a* to *f*.

At any convenient point draw H M in length equal to B N of elevation, and lay off M K at right angles to it, and from the point M mark off the base line of triangles, as shown in plan; that is, make M I equal to 8 1 of plan, M 7, 14 7, etc., and draw lines from these seven points to H. In a similar manner construct a corresponding section as shown by G I J, the distance from L to *a* being the same as from 8 to 2 of plan, L to *f* the distance from 13 to 7 of plan. For convenience dotted lines can be drawn from the points *a b c*, etc., to G.

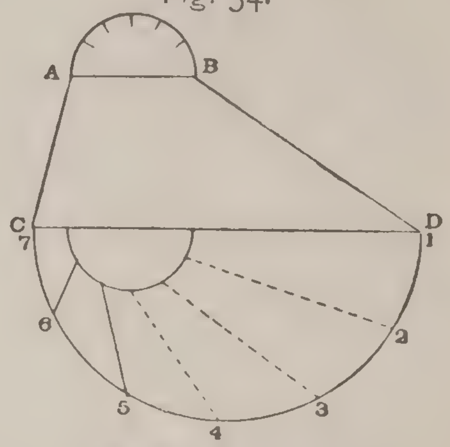
To make a model illustrating the method used to describe the pattern for the can top, cut a piece of tin the shape shown in Fig. 54, which is to be spaced off the same as the plan, and bent on the lines A B and C D, as shown at K, Fig. 55, which is an end view. Pieces of tin representing the triangles H M 2 to H M 6 are to be cut and soldered in

Fig. 53.



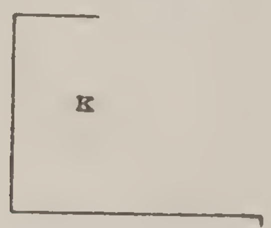
Half of pattern.

Fig. 54.



Pattern for model.

Fig. 55.



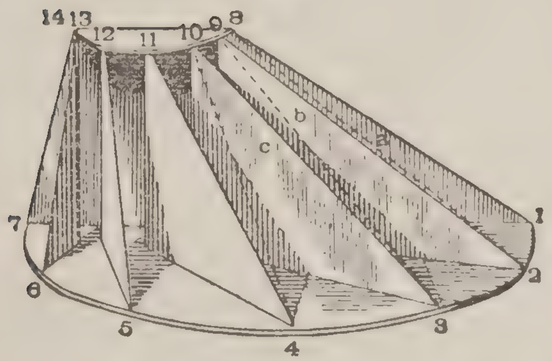
End view of Fig. 54.

their respective positions on the model, as shown by the perspective of model in Fig. 56. It will be noticed that Fig. 54 has the two triangles H M 7 and H M 1. If desired, pieces of tin can be cut to represent the triangles G L *a*, etc., and soldered in position on model as shown by dotted lines *a b c*. After the model is finished it will present almost every view that could be desired. By wrapping a piece of paper about the model, and rubbing over with the hand, and then making the various lines with a pencil, a pattern similar to Fig. 53 will be the result.

To describe the pattern proceed as follows: At any convenient place draw the straight line B^1 D^1, Fig. 53, in length equal to B D of elevation, H 1 of solid triangles, or 8 1 of model. The next step in obtaining the pattern is to get the length and location of line 2′ 9′ on pattern. To do this, with B^1 as centre, with G *a* of the first diagram, de-

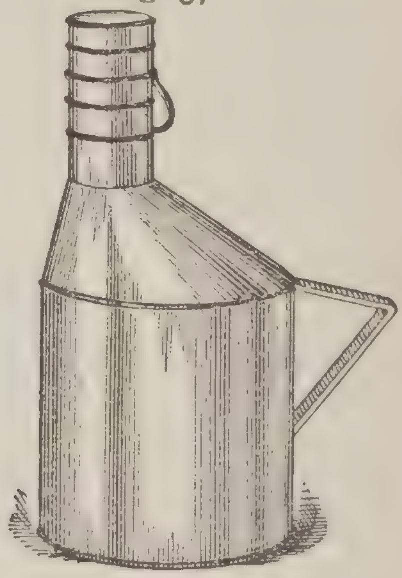
scribe an arc which, intersected by a second arc struck from D^1 as centre, with radius 1 2 of plan, thus establishing point 2′ of pattern. Then, with radius H 2 of the second diagram, from 2′ of the pattern for centre, describe an arc, which cut with another arc struck from 8′ of the pattern as centre, and 8 9 of the plan as radius, thus locating the point 9′ of pattern. This process is to be continued from 2′ 3′, 9′ 3′, until the location of all of the points in plan, from 1 to 7 and 8 to 14,

Fig. 56.



Model showing location of triangles on plan.

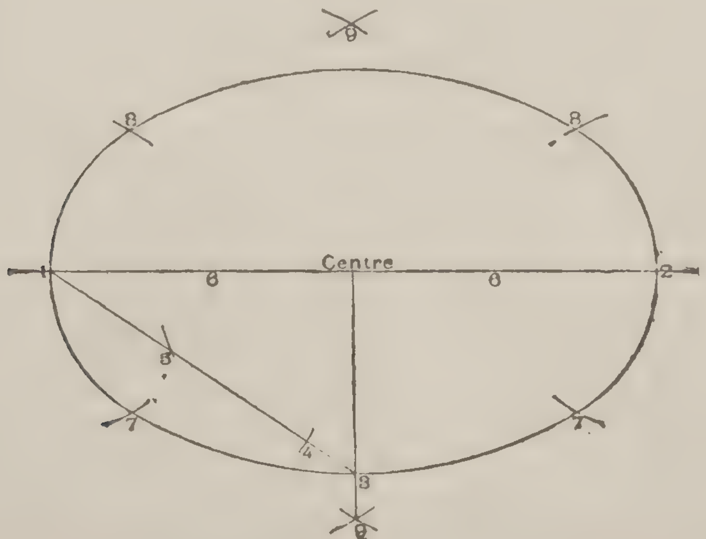
Fig 57.



The finished article.

have been laid off. Referring to the model, it will be noticed that we first lay off the length of line 8 1, then an arc using length of dotted line *a* until it intersects with arc from 1 to 2, using 1 as a centre. Then the length of line 2 9 (second diagram H 2) is located by using the distance from 8 to 9 of plan as an arc, thus establishing various points necessary, so that a line drawn free-hand from D^1 to C^1, and from B^1 to A^1, and being connected by straight lines from the points B^1 to D^1 and A^1 to C^1, will give one-half of the desired pattern.

Fig. 58.



To Draw an Oval with Square and Circle.—Draw the line

from 1 to 2, which is the length of the oval. Draw line from centre to 3, which is one-half the width, and draw line from 1 to 3. Set compass from 1 to centre, leave one point on 1 and mark 4. Set compass from centre to 3. Leave 1 end (of compass) in centre and mark 5. Set compass from 4 to 5, and from 6 draw head lines of circles 7 and 8, and 7 and 8 from points 1 and 2. Set compass from 7 to 7, and mark 9 from 7 7 and 8 8. Complete oval from 9.

Explanation of Equations and Proportions.

An equation is an expression of the fact that a certain quantity or combination of quantities is equal to and equalled by another quantity or combination of quantities.

$9 + 7 = 16$; $a\ b\ c = x$; $4 \times 15 = 60$, are equations, the values to the left of the $=$ sign being called the first member and those to the right the second member of the equation. A little consideration will make it evident that the same or equal quantities may be added to or subtracted from both members, and that both members may be multiplied or divided by the same or equal values without destroying their equality.

A *term* is a quantity which is united to other quantities by addition or subtraction; a *factor* is a quantity which is united to other quantities by multiplication. In the examples given 9 and 7 in the first are *terms*, 4 and 15 in the last are *factors*.

A little further consideration will show that a term can be transposed from one member of an equation to another by changing its sign, without affecting the equality of its members. In the first example given, if $9 + 7 = 16$, it is equally true that $9 = 16 - 7$, or $7 = 16 - 9$.

It is also true that factors may be transposed from one member to another by making them divisors in the new member when they were multipliers in the old, and multipliers in the new when they were divisors in the old. In the equation $4 \times 15 = 60$, if we reduce the first member by removing the 4, it is evident that its value is only $\frac{1}{4}$ of what it was when multiplied by that number, and in order to make the 60 equal to its new value we must divide by 4; so we see that if $4 \times 15 = 60$, then $15 = \frac{60}{4}$, or $4 = \frac{60}{15}$.

To solve an equation, we transpose so as to bring the known quantities on to one side and the unknown quantity on to the other, showing the value of the unknown quantity by its equality with the known. Suppose in the first example the 9 were missing, represent it, say, by x and write

$$x + 7 = 16$$
$$x = 16 - 7, \text{ transposed}$$
$$x = 9$$

Example.—A pump cylinder contains 225 square inches cross sectional area. How large a cylinder must be added to make the aggregate area equal to one cylinder of 340 square inches?

Expressed as an equation this would be

$$x + 225 = 340$$
$$x = 340 - 225$$
$$x = 115$$

The greatest longitudinal section of a boiler contains 90 square feet. Its length is 15 feet. What is the diameter?

Since the product of the length by the diameter will equal the area, we have

$$15\,x = 90$$
$$x = \frac{90}{15}$$
$$x = 6$$

Proportions.—In books which treat of engineering subjects there is frequently seen an arrangement like the following:

$$4 : 8 :: 12 : 24$$

This is a statement of proportion, and is read, "as 4 is to 8 so is 12 to 24," signifying that 4 bears the same relation to 8 as 12 does to 24; in this instance $\frac{1}{2}$ in each case.

In the proportion as expressed above, the two outside figures 4 and 24 are called the "extremes" and the included numbers 8 and 12 the "means," and the product of the means is always equal to the product of the extremes when the numbers are in proportion.

$$4 \times 24 = 96$$
$$8 \times 12 = 96$$

If one of the numbers in the proportion is missing, we can determine its value by dividing it into the product of the other two. Suppose the 24 gone in the above proportion and write

$$4 : 8 :: 12 : x$$
$$\text{then} \quad x \times 4 = 8 \times 12$$
$$x \times 4 = 96$$
$$x = \frac{96}{4}$$
$$x = 24$$

Example.—In rigging up for indicating with a pendulum lever, the distance from the centre of the pin on which the pendulum swings to the point where the cord is attached to it must be to the whole length of the lever as the desired length of card is to the stroke of the engine. Suppose with a lever 96 inches long on an engine of 48 inches stroke it is desired to get a card 4 inches in length. How far from the point of suspension would you attach the cord?

$$48 : 4 :: 96 : x$$
$$x = \frac{4 \times 96}{48}$$
$$x = 8 \text{ inches}$$

These proportions may be expressed as follows:

$$\frac{4}{8} = \frac{12}{24} \text{ and } \frac{48}{4} = \frac{96}{8}$$

Values are sometimes inversely proportional. An instance of this occurs when a gas expands by Mariotte's law, for when you double the volume instead of *doubling* the pressure, you *halve* it; and when you expand to three volumes you divide instead of multiplying the pressure by three. The proportion here then is

$$P_1 : P_2 :: V_2 : V_1$$

or, taking 2 cubic feet of air at 40 lbs. pressure and expanding it to 4 cubic feet, we have for the new pressure:

$$2 : 4 :: x : 40$$

It will be noticed that as the product of the extremes equals the product of the means, the product of the first volume by the first pressure equals the product of the second volume by the second pressure, etc.; or

$$P_0 V_0 = P_1 V_1 = P_2 V_2$$

and thus we see that in hyperbolic expansion the products of the pressures and volumes are constant.

Another case of inverse proportion is found in the lever, for the weight or pressure which will balance another on a lever is inversely proportional to its distance from the fulcrum or point upon which the lever turns. The *shorter* the distance the greater the pressure necessary to lift a certain load. As in the case of the volumes and pressures, the product of the weight necessary with a certain load to produce equilibrium, multiplied by its distance from the fulcrum, will always be constant and equal to the product of the balanced load into its distance from the fulcrum.

Weight and Specific Gravity.

The specific gravity of a body is the ratio which the weight of the body bears to the weight of another body of equal volume adopted as a standard for the comparison of the weights of bodies. For solids and liquids, pure water at the mean temperature 62° F. is adopted as the standard body for comparative weight. For gases, dry air at 32° F., and under one atmosphere of pressure, or 14.7 lbs. per square inch, is the body with which they are compared.

The specific gravity of bodies is found by weighing them in and out of water, according to the following rules:

RULE 1. *To find the specific gravity of a solid body heavier than water.*—Weigh it in pure water at 62° F., and divide its weight out of water by the loss of weight in the water. The quotient is the specific gravity.

Note.—The loss of weight in water is the difference of the weight in air and the weight in water, and it is equal to the weight of the quantity of water displaced, which is equal in volume to the body.

RULE 2. *To find the specific gravity of a solid body lighter than water.*—Load it so as to sink it in pure water at 62° F., and weigh it and the load together, out of water, and in water; weigh the load separately in and out of water; deduct the loss of weight of the load singly from that of the combined body and load; the remainder is the loss of weight of the body singly, by which its weight out of water is to be divided. The quotient is the specific gravity.

RULE 3. *To find the specific gravity of a body which is soluble in water.*—Weigh it in a liquid in which it is not soluble, divide the weight out of the liquid by the loss of weight in the liquid and multiply by the specific gravity of the liquid. The product is the specific gravity of the body.

RULE 4. *To find the specific gravity of a liquid.*—Weigh a solid body in the liquid and in water, as well as in the air, and divide the loss of weight in the liquid by the loss of weight in water. The quotient is the specific gravity.

RULE 5. *To find the weight of a body when the specific gravity is given.*—Multiply the specific gravity by

Multiplier.		Weight of
62.355 (the weight in pounds of a cubic foot of pure water at 62° F.)	=	1 cubic foot in lbs.
1683.60	=	1 cubic yard " "
15.0	=	1 " " cwts.
0.75	=	1 " " tons.

Note.—As one cubic foot of water at 62° F. weighs about 1000 ounces (exactly 997.68 ounces), the weight in ounces of a cubic foot of any other substance will represent, approximately, its specific gravity, supposing water = 1000.

If the last three places of figures be pointed off as decimals, the result will be the specific gravity approximately, water being = 1.

The densities of metals vary greatly. Potassium and one or two others are lighter than water. Platinum is more than twenty times as heavy. Lead is over eleven times as heavy; and the majority of the useful metals are from seven to eight times as heavy as water.

Stones for building and other purposes vary in weight within much narrower limits than metals. With one exception, they vary from basalt and granite, which are three times the weight of water, to volcanic scoriæ, which are lighter than water. The exception referred to is barytes, which is conspicuously the heaviest stone, being 4½ times as heavy as water. The sulphate of baryta is known as heavy spar.

Amongst other solids, flint glass has three times the weight of water; clay and sand twice as much; coal averages one and a half times the weight of water; and coke from one to one and a half times. Camphor has about the same weight as water.

Of the precious stones, zircon is the heaviest, having four and a half times the weight of water; garnet is four times as heavy; diamond three and a half times as heavy; and opal, the lightest of all, has just twice the weight of water.

Peat varies in weight from one-fifth to a little more than the weight of water.

The heaviest wood is that of pomegranate, which has one and a third times the weight of water. English oak is nearly as heavy as water, and heart of oak is heavier; the densest teak has about the same weight as water; mahogany averages about three-fourths, elm over a half, pine from a half to three-fourths, and cork one-fourth of the weight of water.

Wood charcoal in powder averages one and a half times the weight of water; in pieces heaped, it averages only two-fifths. Gunpowder has about twice the weight of water.

Of animal substances, pearls weigh heaviest, two and three-quarter times the weight of water; ivory and bone twice, and fat over nine-tenths the weight of water.

Of vegetable substances, cotton weighs about twice as much as water; gutta percha and caoutchouc nearly the same as water.

Mercury, the heaviest liquid at ordinary temperatures, has over thirteen and a half times the weight of water, and bromine nearly three times the weight. The water of the Dead Sea is a fourth heavier and ordinary sea-water 2½ per cent. heavier than water; whilst olive oil is about one-tenth lighter, and pure alcohol and wood spirit is a fifth lighter than water.

Turning to gaseous bodies, water at 62° F. has 772.4 times the weight of air at 32° F. under a pressure of one atmosphere; and the specific gravity of air at 32° F. is 0.001293, that of water at 62° F. being = 1. Oxygen gas weighs a tenth more than air, gaseous steam weighs only five-eighths of air, and hydrogen, the most perfect type of gaseity, has only seven per cent. of the weight of air. Water has upwards of 11,000 times the weight of hydrogen.

One pound of air at 62° F. has the same volume as a ton of quartz.

The specific gravity of alloys does not usually follow the ratio of those of their constituents; it is sometimes greater and sometimes less than the mean of these. The following are the specific gravities of the alloys as ascertained by Crookewitt:

	Specific gravity.
Copper	8.794
Tin	7.305
Zinc	6.860
Lead	11.354
Alloys:—Copper 2, tin 5	7.652
Copper 1, tin 1	8.072
Copper 2, tin 1	8.512
Copper 3, zinc 5	7.939
Copper 3, zinc 2	8.224
Copper 2, zinc 1	8.392
Copper 2, lead 3	10.753
Copper 1, lead 1	10.375
Tin 1, zinc 2	7.096
Tin 1, zinc 1	7.115
Tin 3, zinc 1	7.235
Tin 1, lead 2	9.965
Tin 1, lead 1	9.394
Tin 2, lead 1	9.025

The following binary alloys have, on the one side, a density greater than the mean density of their constituents; and, on the other side, a density less than the mean density of the constituents.

Alloys having a density greater than the mean.	*Alloys having a density less than the mean.*
Gold and zinc.	Gold and silver.
Gold and tin.	Gold and iron.
Gold and bismuth.	Gold and lead.
Gold and antimony.	Gold and copper.
Gold and cobalt.	Gold and iridium.
Silver and zinc.	Gold and nickel.
Silver and lead.	Silver and copper.
Silver and tin.	Iron and bismuth.
Silver and bismuth.	Iron and antimony.
Silver and antimony.	Iron and lead.
Copper and zinc.	Tin and lead.
Copper and tin.	Tin and palladium.
Copper and palladium.	Tin and antimony.
Copper and bismuth.	Nickel and arsenic.
Lead and antimony.	Zinc and antimony.
Platinum and molybdenum.	
Palladium and bismuth.	

VOLUME, WEIGHT AND SPECIFIC GRAVITY OF SOLID BODIES.

FAMILIAR METALS.	Weight of one cubic foot.	Specific gravity.
	Pounds.	Water = 1.
Platinum	1342	21.522
Gold	1200	19.245
Mercury, fluid	849	13.596
Lead, milled sheet	712	11.418
" wire	704	11.282
Silver	655	10.505
Bismuth	617	9.90
Copper:—Sheet	549	8.805
Hammered	556	8.917
Wire	554	8.880
Bronze:—84 copper, 16 tin, gun metal	534	8.56
83 " 17 " " "	528	8.46
81 " 19 " " "	528	8.46
79 " 21 " mill bearings	544	8.73
35 " 65 " small bells...	503	8.06
21 " 79 " " " ...	461	7.39
15 "85 tin, speculum metal	465	7.45
Nickel, hammered	541	8.67
" cast	516	8.28
Brass:—Cast	505	8.10
75 copper, 25 zinc, sheet	527	8.45
66 " 34 " yellow	518	8.30
60 " 40 " Muntz's metal	511	8.20
Brass wire	533	8.548
Manganese	499	8.00
Steel:—Least and greatest density	435 to 493	7.729 to 7.904
Homogeneous metal	493	7.904
Blistered steel	488	7.823
Crucible steel	488 to 490	7.825 to 7.859
" steel, average	489	7.842
Cast steel	489 to 489.5	7.844 to 7.851
" steel, average	489.3	7.848
Bessemer steel	489 to 490	7.844 to 7.857
" steel, average	489.6	7.852
mean for ordinary calculations	489.6	7.852
Iron:—Wrought, least and greatest density	466 to 487	7.47 to 7.808
" common bar	471	7.55
" puddled slab	469.5 to 474	7.53 to 7.60
" various, irons tested by Kirkaldy	468 to 486	7.5 to 7.8
" various, average	477	7.65
" common rails	466 to 476	7.47 to 7.64
" " rails, average	470	7.54
" Yorkshire iron bar	484	7.758
" Low Moor plates, 1½ to 3 inches thick	487	7.808

FAMILIAR METALS.	Weight of one cubic foot.	Specific gravity.
	Pounds.	Water = 1.
Iron:—Wrought, Beale's rolled iron.	476	7.632
" pure iron (exceptional) by electro-deposit (Dr. Percy)	508	8.140
" mean for ordinary calculations	480	7.698
Iron:—Cast, least and greatest density	378.25 to 467.66	6.900 to 7.500
" white........................	468	7.50
" gray	449	7.20
" Eglinton hot blast, first melting	435	6.969
" Eglinton hot blast, second melting	435	6.970
" Eglinton hot blast, fourteenth melting..	470	7.530
" Rennie........................	435 to 444	6.977 to 7.113
" Mallet	442	7.094
" mean for ordinary calculations	450	7.217
Tin..	462	7.409
Zinc, sheet..................................	449	7.20
" cast..................................	428	6.86
Antimony..................................	418	6.71
Aluminium, wrought........................	167	2.67
" cast........................	160	2.56
Magnesium................................	108.5	1.74
OTHER METALS.		
Iridium....................................	1165.0	18.68
Uranium....................................	1147.0	18.40
Tungsten....................................	1097.0	17.60
Thallium....................................	742.6	11.91
Palladium....................................	735.8	11.80
Rhodium....................................	660.9	10.60
Osmium....................................	623.6	10.00
Cadmium....................................	542.5	8.70
Molybdenum....................................	537.5	8.62
Ruthenium....................................	536.2	8.60
Cobalt....................................	530.0	8.50
Tellurium....................................	381.0	6.11
Chromium....................................	374.1	6.00
Arsenic....................................	361.5	5.80
Titanium....................................	330.5	5.30
Strontium....................................	158.4	2.54
Glucinum....................................	131.0	2.10
Calcium....................................	98.5	1.58
Rubidium....................................	94.8	1.52
Sodium....................................	60.5	0.97
Potassium....................................	53.6	0.86
Lithium....................................	37.0	0.59

PRECIOUS STONES.

NAME.	Specific gravity.	NAME.	Specific gravity.
Zircon	4.50	Diamond, pure	3.52
Garnet	3.60 to 4.20	Boart	3.50
Malachite	4.01	Topaz	3.50
Sapphire	3.98	Tourmaline	3.07
Emerald	3.95	Lapis lazuli	2.96
" aqua-marine	2.73	Turquoise	2.84
Amethyst	3.92	Jasper, onyx, agate	2.6 to 2.7
Ruby	3.95	Beryl	2.68
Diamond	3.50 to 3.53	Opal	2.09

STONES.

NAME.	Cubic feet to one ton, solid.	Weight of one cubic foot, solid.	Specific gravity.
	Cubic feet.	Pounds.	Water = 1.
Specular or red iron ore	6.84	327.4	5.251
Magnetic iron ore	7.05	317.6	5.094
Brown iron ore	9.16	244.6	3.922
Spathic iron ore	9.38	238.8	3.829
Clydesdale iron ores	11.76	190.5	3.055 to 3.380
Barytes	8.07	277.5	4.45
Basalt	14.7 to 12.0	152.8 to 187.1	2.45 to 3.00
Mica	14.0 to 12.3	160.3 to 182.7	2.57 to 2.93
Limestone, magnesian	12.6	178.3	2.86
" carboniferous	13.3	168.0	2.69
Marble, Paros	12.7	177.1	2.84
" African	12.8	174.6	2.80
" Siberian	13.2	170.2	2.73
" Pyrenian	13.2	170.2	2.73
" Carrara	13.2	169.6	2.72
" Egyptian, green	13.5	166.5	2.67
" French	13.6	165.2	2.65
" Florentine, Sienna	14.3	157.1	2.52
Trap, touchstone	13.2	169.6	2.72
Granite, Sienite, Gneiss	15.2 to 12.1	147.1 to 184.6	2.36 to 2.96
" Gray	12.8 to 11.8	174.6 to 190.8	2.80 to 3.06
Porphyry	13.5 to 13.1	166.5 to 171.5	2.67 to 2.75
Alabaster, calcareous	13.0	172.1	2.76
" gypseous	15.6	144.0	2.31
Chalk, air-dried	14.9 to 14.1	150 to 159	2.46 to 2.55
Slate	13.8 to 12.6	162.1 to 177.7	2.60 to 2.85
Serpentine	12.8	175.2	2.81
Potter's stone	12.8	174.6	2.80

STONES.	Cubic feet to one ton, solid.	Weight of one cubic foot, solid.	Specific gravity.
	Cubic feet.	Pounds.	Water = 1.
Schist, slate	12.8	174.6	2.80
" rough	19.9 to 12.9	112.8 to 173.3	1.81 to 2.78
Lava, Vesuvian	21.0 to 12.8	106.6 to 175.2	1.71 to 2.81
Talc, steatite	13.3	168.4	2.70
Rock crystal	13.6	165.2	2.65
Quartz	13.8 to 13.3	162.8 to 169.0	2.61 to 2.71
" crystalline	13.6	165.2	2.65
" for paving	14.4	155.9	2.50
" porous, for mill-stones	28.5	78.6	1.26
Quartz, flaky, for mill-stones	14.1	159.0	2.55
Flint	13.7	164.0	2.63
Felspar	13.8	162.1	2.60
Gypsum	15.6	143.4	2.30
Lias	16.0 to 14.7	140.3 to 152.8	2.25 to 2.45
Graphite	16.3	137.2	2.20
Sandstone	17.3 to 14.3	129.7 to 157.1	2.08 to 2.52
Tufa, volcanic	29.7 to 26.1	75.4 to 86.0	1.21 to 1.38
Scoria, "	43.3	51.7	0.83

SUNDRY MINERAL SUBSTANCES.

NAME.	Cubic feet to one ton, solid.	Weight of one cubic foot, solid.	Specific gravity.
		Pounds.	Water = 1.
Glass: Flint	....	187.0	3.00
" Green	....	168.4	2.70
" Plate	....	168.4	2.70
" Crown	....	155.9	2.50
" St. Gobain	....	155.3	2.49
" Common with base of potash	....	153.4	2.46
" Fine with base of potash	....	152.8	2.45
" Common with base of soda	....	152.8	2.45
" Fine with base of soda	....	152.1	2.44
" Soluble	....	77.9	1.25
Porcelain: China	....	148.4	2.38
" Sevres	....	139.7	2.24
Portland cement	28.7 to 23.8	78 to 94	1.25 to 1.51
Concrete: P. cement 1, and shingle 10	16.1	139	2.23

SUNDRY MINERAL SUBSTANCES.	Cubic feet to one ton, solid.	Weight of one cubic foot, solid.	Specific gravity.
		Pounds.	Water = 1.
Concrete: P. cement, rubble and sand..	16.6 to 16.0	135 to 140	2.17 to 2.25
" P. cement 1, and sand 2..........	17.6	127	2.04
" Roman cement 1, and sand 2..	18.7	120	1.92
Mortar	20.6	109	1.75
Brick	18.1 to 16.0	124.7 to 135.3	2.00 to 2.17
Brickwork	20.4 to 19.5	110 to 115	1.76 to 1.84
Masonry, rubble	19.4 to 15.6	115.3 to 143.4	1.85 to 2.30
Marl	22.4 to 18.9	99.8 to 118.5	1.60 to 1.90
" very tough	15.3	146	2.34
Potash	17.1	131	2.10
Sulphur	18.0	124.7	2.00
Tiles	18.0	124.7	2.00
Rock salt	17.1 to 15.9	131 to 140.7	2.100 to 2.257
Common salt, as a solid.....	18.7	119.7	1.92
Clay	18.7	119.7	1.92
Sand, pure	18.9	118.5	1.90
" earthy	21.1	106.0	1.70
Earth, Potter's	18.9	118.5	1.90
" argillaceous	22.4	99.8	1.60
" light vegetable	25.7	87.3	1.40
Mud	22.0	101.6	1.63
Wet, fine, sharp gravel, well pressed	18	124	1.99
Wet, running mud..	18.1	122.5	1.97
Alluvial earth, pressed......	24	93.0	1.49
" " loose	33	67	1.08
Plaster: 24 hours after using	22.6	99.2	1.59
" 2 months after using	25.7	87.3	1.40
Coke	39 to 21.6	57.4 to 103.5	0.92 to 1.66
Phosphorus	20.3	110.4	1.77
Alum	20.9	107.2	1.72
Camphor	36.3	61.7	0.99
Melting ice	39	57.5	0.922

WOODS.

NAME.	Weight of one cubic foot.	Specific gravity.
	Pounds.	
Pomegranate	84.2	1.35
Boxwood	64.8	1.04
" of Holland	82.3	1.32

Woods.	Weight of one cubic foot.	Specific gravity.
	Pounds.	
Boxwood of France	56.7	0.91
Lignum vitæ	40.5 to 82.9	0.65 to 1.33
Ebony	70.5	1.13
Ebony, green	75.5	1.21
" black	74.2	1.19
Oak, heart of	73.0	1.17
" English	58.0	0.93
" European	43.0 to 61.7	0.69 to 0.99
" American, red	54.2	0.87
Lancewood	41.8 to 63.0	0.67 to 1.01
Rosewood	64.2	1.03
Satin-wood	59.9	0.96
Walnut, green	57.4	0.92
" brown	42.4	0.68
Laburnum	57.4	0.92
Hawthorn	56.7	0.91
Mulberry	55.5	0.89
Plum tree	54.2	0.87
Teak, African	....	0.98
Mahogany, Spanish	53.0	0.85
" St. Domingo	46.8	0.75
" Cuba	34.9	0.56
" Honduras	34.9	0.56
Beech	46.8 to 53.0	0.75 to 0.85
" with 20 per cent. moisture	51.1	0.82
" cut one year	41.2	0.66
Ash	52.4	0.84
" with 20 per cent. moisture	43.7	0.70
Acacia	51.1	0.82
" with 20 per cent. moisture	44.9	0.72
Holly	47.5	0.76
Hornbeam	47.5	0.76
Yew	46.1 to 50.5	0.74 to 0.81
Birch	44.9 to 46.1	0.72 to 0.74
Elm	34.3	0.55
" green	47.5	0.76
" with 20 per cent. moisture	44.9	0.72
Yoke elm " " "	47.5	0.76
Rock elm	50.0	0.80
Fir, Norway pine	46.1	0.74
" red pine	29.9 to 43.7	0.48 to 0.70
" spruce	29.9 to 43.7	0.48 to 0.70
" larch	31.18 to 39.9	0.50 to 0.64
" white pine, English	34.3	0.55
" " " Scotch	34.3	0.53
" " " " with 20 per cent. moisture	30.6	0.49
" yellow pine	41.2	0.66
" " " American	28.7	0.46

Woods.	Weight of one cubic foot.	Specific gravity.
American pine wood in cord (heaped)	21	0.34
Apple tree	45.5	0.73
Pear tree	45.5	0.73
Orange tree	44.3	0.71
Olive tree	42.4	0.68
Maple	40.5	0.65
" with 20 per cent. moisture	41.8	0.67
Service tree	41.8	0.67
Cypress, cut one year	41.2	0.66
Plane tree	40.5	0.65
Vine tree	37.4	0.60
Aspen tree	37.4	0.60
Alder tree	34.9	0.56
" with 20 per cent. moisture	37.4	0.60
Sycamore	36.8	0.59
Cedar of Lebanon	30.6 to 35.5	0.49 to 0.57
Bamboo	19.5 to 24.9	0.31 to 0.40
Poplar	24.3	0.39
" White	20.0 to 31.8	0.32 to 0.51
" with 20 per cent. moisture	29.9	0.48
Willow	30.6	0.49
Cork	15.0	0.24
Elder pith	4.74	0.076

Wood Charcoal.

Wood Charcoal (as powder).	Weight of one cubic foot.	Specific gravity.
	Pounds.	Water = 1.
Willow	96.7	1.55
Oak	95.4	1.53
Alder	92.9	1.49
Lime tree	91.0	1.46
Poplar	90.4	1.45
Average of 5 charcoals	93.5	1.50

Wood Charcoal (as made, heaped).	Weight of one cubic foot.	Specific gravity.
	Pounds.	
Oak and beech	15 to 15.6	0.24 to 0.25
Birch	13.7 to 14.3	0.22 to 0.23
Pine	12.5 to 13.1	0.20 to 0.21
Average	14	0.225

Wood Charcoal.

Wood Charcoal (in small pieces, heaped).	Weight of one cubic foot.	Specific gravity.
	Pounds.	
Walnut	39.3	0.63
Ash	34.3	0.55
Beech	32.5	0.52
Yoke elm	28.7	0.46
Apple tree	28.7	0.46
White oak	26.2	0.42
Cherry tree	25.6	0.41
Birch	22.5	0.36
Elm	22.5	0.36
Yellow pine	20.6	0.33
Chestnut tree	17.5	0.28
Poplar	15.6	0.25
Cedar	15.0	0.24
Average of 13 charcoals	25.3	0.405
Gunpowder	109.1 to 114.7	1.75 to 1.84

Animal Substances.

Names.	Weight of one cubic foot.	Specific gravity.
	Pounds.	
Pearls	169.6	2.72
Coral	167.7	2.69
Ivory	119.7	1.92
Bone	112.2 to 124.7	1.80 to 2.00
Wool	100.4	1.61
Tendon	69.8	1.12
Cartilage	68.0	1.09
Crystalline humor	67.3	1.08
Human body	66.7	1.07
Nerve	64.9	1.04
Wax	59.9	0.96
White of whalebone	58.7	0.94
Butter	58.7	0.94
Pork fat	58.7	0.94
Mutton fat	57.4	0.92
Animal charcoal in heaps	50 to 52	0.80 to 0.83

Vegetable Substances.

Names.	Weight of one cubic foot.	Specific gravity.
	Pounds.	
Cotton	121.6	1.95
Flax	111.6	1.79
Starch	95.4	1.53
Fecula	93.5	1.50
Gum-Myrrh	84.8	1.36
" Dragon	82.3	1.32
" Dragon's blood	74.8	1.20
" Sandarac	68.0	1.09
" Mastic	66.7	1.07
Resin-Jalap	76.1	1.22
" Guayacum	74.8	1.20
" Benzoin	68.0	1.09
" Colophony	66.7	1.07
Amber, opaque	68.0	1.09
" transparent	67.3	1.08
Gutta percha	60.5	0.97
Caoutchouc	58.0	0.93
Grain, Wheat, heaped	46.7	0.75
" Barley "	36.6	0.59
" Oats, "	31.2	0.50

WEIGHT AND SPECIFIC GRAVITY OF LIQUIDS.

Liquids at 32° F.	Weight of one cubic foot.	Weight of one gallon.	Specific gravity.
	Pounds.	Pounds.	Water = 1.
Mercury	848.7	136.0	13.596
Bromine	185.1	29.7	2.966
Sulphuric acid, maximum concentration	114.9	18.4	1.84
Nitrous acid	96.8	15.5	1.55
Chloroform	95.5	15.3	1.53
Water of the Dead Sea	77.4	12.4	1.24
Nitric acid of commerce	76.2	12.2	1.22
Acetic acid, maximum concentration	67.4	10.8	1.08
Milk	64.3	10.3	1.03
Sea water, ordinary	64.05	10.3	1.026
Pure water (distilled) at 39.1° F.	62.425	10.0	1.000
Wine of Bordeaux	62.1	9.9	0.994
" of Burgundy	61.9	9.9	0.991
Oil, linseed	58.7	9.4	0.94
" poppy	58.1	9.3	0.93

LIQUIDS AT 32° F.	Weight of one cubic foot.	Weight of one gallon.	Specific gravity.
	Pounds.	Pounds.	Water = 1.
Oil, rape seed	57.4	9.2	0.92
" whale	57.4	9.2	0.92
" olive	57.1	9.15	0.915
" turpentine	54.3	8.7	0.87
" potato	51.2	8.2	0.82
Petroleum	54.9	8.8	0.88
Naphtha	53.1	8.5	0.85
Ether, nitric	69.3	11.1	1.11
" sulphurous	67.4	10.8	1.08
" nitrous	55.6	8.9	0.89
" acetic	55.6	8.9	0.89
" hydrochloric	54.3	8.7	0.87
" sulphuric	44.9	7.2	0.72
Alcohol, proof spirit	57.4	9.2	0.92
" pure	49.3	7.9	0.79
Benzine	53.1	8.5	0.85
Wood spirit	49.9	8.0	0.80

WEIGHT AND SPECIFIC GRAVITY OF GASES AND VAPORS.

GASES AT 32° F. AND UNDER ONE ATMOSPHERE OF PRESSURE.	Volume of one pound weight.	Weight of one cubic foot.		Specific gravity.
	Cubic feet.	In pounds.	In ounces.	Air = 1.
Vapor of mercury (ideal)	1.776	0.563	9.008	6.9740
Vapor of bromine	2.236	0.447	7.156	5.5400
Chloroform	2.337	0.428	6.846	5.3000
Vapor of turpentine	2.637	0.378	6.042	4.6978
Acetic ether	4.075	0.245	3.927	3.0400
Vapor of benzine	4.598	0.217	3.480	2.6943
Vapor of sulphuric ether	4.790	0.209	3.340	2.5860
Vapor of ether (?)	4.777	0.206	3.302	2.5563
Chlorine	5.077	0.197	3.152	2.4400
Sulphurous acid	5.513	0.1814	2.902	2.2470
Alcohol	7.679	0.1302	2.083	1.6130
Carbonic acid (actual)	8.101	0.12344	1.975	1.5290
" " (ideal)	8.157	0.12259	1.961	1.5186
Oxygen	11.205	0.089253	1.428	1.1056
Air	12.387	0.0800728	1.29165	1.0000
Nitrogen	12.723	0.078596	1.258	0.9736
Carbonic oxide	12.804	0.0781	1.250	0.9674
Olefiant gas	12.580	0.0795	1.272	0.9847
Gaseous steam	19.913	0.05022	0.8035	0.6220
Ammoniacal gas	21.017	0.04758	0.7613	0.5894
Light carburetted hydrogen	22.412	0.04462	0.7139	0.5527
Coal gas	28.279	0.03536	0.5658	0.4381
Hydrogen	178.83	0.005592	0.0895	0.0692

BOILING POINTS OF LIQUIDS.

When the temperature of a liquid is raised to the boiling point the temperature ceases to rise, and remains constant and stationary, although the liquid continues to receive heat, until the whole of the liquid is evaporated. The boiling points of liquids are always greater when they contain matters in chemical combination, but the boiling point is not altered by the presence of foreign bodies, such as carbonate of lime and sand, mechanically mixed with them. The boiling points of various liquids under one atmosphere of pressure are given in the following table, the results of experiments by Regnault, Dalton, etc.:

Boiling Points of Liquids at Atmospheric Pressure.

Description of liquid.	Fah.	Description of liquid.	Fah.
Sulphuric ether	100°	Sea water, average	213°
Sulphuret of carbon	118	Saturated brine	226
Ammonia	140	Nitric acid	248
Chloroform	140	Oil of turpentine	315
Bromine	145	Phosphorus	554
Wood spirit	150	Sulphur	570
Alcohol	173	Sulphuric acid	590
Benzine	176	Linseed oil	597
Water	212	Mercury	648

The high temperature of oil renders it useful for some tempering and cooking purposes.

The steam from the surface of salt water contains no salt, and has an invariable temperature of 212° F., although the temperature of the solution is much higher.

Boiling Points of Solutions of Soda, etc.

	Proportionate quantity in 100 parts by weight of water.	Boiling points.
Salts in sea water	3.03	213.2° F.
In common water:		
Sulphate of soda	31.5	213° F.
Sulphate of iron	64	216
Alum	52	220
Sulphate of lime	45	220
Sulphate of magnesia	57.5	222
Muriate of soda	30	224
Nitrate of soda	60	246
Acetate of soda	60	256

Elastic Force of Steam in Inches of Mercury.

Common water / Sea water	boiling point, 212° F. / at 212° F.	elastic force, 30 inches. / " " 23.05 "
Common water / Sea water	boiling point, 216° F. / at 216° F.	elastic force, 32.05 inches. / " " 24.06 "

Elastic Force of Steam in Inches of Mercury.

Common water	boiling point, 220° F.	elastic force, 35.1 inches.
Sea water	at 220° F.	" " 26.5 inches.

Hence the propriety of procuring, for steam, water in its purest state.

RULES RELATING TO LIGHT, HEAT, COLD, ETC.

Luminosity at High Temperatures.

The luminosity or shades of temperature have been observed by M. Poulet by means of an air-pyrometer to be as follows:

Shade.	Temperature Centigrade.	Temperature Fahrenheit.
Nascent red	525°	977°
Dark red	700	1292
Nascent cherry red	800	1472
Cherry red	900	1652
Bright cherry red	1000	1832
Very deep orange	1100	2012
Bright orange	1200	2192
White	1300	2372
"Sweating" white	1400	2552
Dazzling white	1500	2732

A bright bar of iron slowly heated, in contact with air, assumes the following tints at annexed temperatures:

	Centigrade.	Fahrenheit.
1. Cold iron at about	12°	54°
2. Yellow at	225	437
3. Orange at	243	473
4. Red at	265	509
5. Violet at	277	531
6. Indigo at	288	550
7. Blue at	293	559
8. Green at	332	630
9. Oxide gray (*gris d'oxyde*) at	400	752

To Determine the Temperature of Porcelain Ovens.—According to Ch. Lauth pyroscopic masses adjusted to the various stages of temperature of the batches of hard porcelain and new porcelain (*porcelaine nouvelle*) have been for several years used at Sèvres. For the preparation of the pyroscopes two glass compositions are required which consist of:

I.		II.	
Pegmatite	51 parts.	Pegmatite	70 parts.
Quartz sand	14 "	Whiting	30 "
Whiting	20 "		
Melted borax	15 "		

The following observations are constant:

1. Composition I melts at exactly 1202° F.
2. Composition I, 15 parts, Composition II, 85 " } thoroughly mixed, melts at 2102° F.
3. Composition II, 80 parts, Kaolin, 20 " } melts at 2192° F.
4. Composition II, 60 parts, Kaolin, 40 " } melts at 2408° F.

To be able to readily distinguish the pyroscopes standing alongside each other, the moistened mixtures are shaped into various forms—disks, pyramids, spheres, etc. The use of these pyroscopes is very advantageous for practical purposes. In regard to observations with metallic pyroscopes Mr. Lauth says: "The hard Sèvres porcelain requires a temperature of 2732° F. because an alloy of 40 parts of gold with 60 of platinum melts completely at this temperature, while an alloy of 30 parts of gold with 70 of platinum only falls together. The new porcelain is finished at a temperature of 2462° F. At this temperature an alloy of 60 parts of gold and 40 of platinum melts, while one of 50 parts of gold and 50 of platinum only falls together."

COMPARATIVE RADIATING OR ABSORBENT AND REFLECTING POWERS OF SUBSTANCES.

Substance.	Power.	
	Radiating or Absorbing.	Reflecting.
Lamp black	100	0
Water	100	0
Carbonate of lead	100	0
Writing paper	98	2
Ivory, jet, marble	93 to 98	7 to 2
Isinglass	91	9
Ordinary glass	90	10
China ink	85	15
Ice	85	15
Gum lac	72	28
Silver leaf on glass	27	73
Cast iron, brightly polished	25	75
Mercury, about	23	77
Wrought iron, polished	23	77
Zinc, polished	19	81
Steel, polished	17	83
Platinum, a little polished	24	76
" deposited on copper	17	83
" in sheet	17	83

SUBSTANCE.	Power	
	Radiating or absorbing.	Reflecting.
Tin	15	85
Brass, cast, dead polished	11	89
" hammered, dead polished	9	91
" cast, bright polished	7	93
" hammered, bright polished	7	93
Copper, varnished	14	86
" deposited on iron	7	93
" hammered or cast	7	93
Gold, plated	5	95
" deposited on polished steel	3	97
Silver, hammered, polished bright	3	97
" cast, polished bright	3	97

RELATIVE INTERNAL HEAT-CONDUCTING POWER OF BODIES.

SUBSTANCE.	Relative conducting power.	SUBSTANCE.	Relative conducting power.
Gold	1000	Zinc	363
Platinum	981	Tin	304
Silver	973	Lead	180
Copper	892	Marble	24
Brass	749	Porcelain	12
Cast iron	562	Terra cotta	11
Wrought iron	374		

LINEAR EXPANSION OF SOLIDS BY HEAT, BETWEEN 32° AND 212° F.

METALS.	Expansion between 32° and 212° F. in common fractions.	Expansion between 32° and 212° F. in a length = 100.	Expansion between 32° and 212° F. in a length of 10 feet.	Expansion for 1° F. in a length of 100 feet.
		Length = 100.	Inch.	Inch.
Zinc, sheet	$\frac{1}{340}$	0.29416	0.353	0.0196
" forged	$\frac{1}{321}$	0.31083	0.374	0.0207
Lead	$\frac{1}{351}$	0.28484	0.342	0.0190

LINEAR EXPANSION OF SOLIDS BY HEAT, BETWEEN 32° AND 212° F.

METALS.	Expansion between 32° and 212° F. in common fractions.	Expansion between 32° and 212° F. in a length = 100.	Expansion between 32° and 212° F. in a length of 10 feet.	Expansion for 1° F. in a length of 100 feet.
		Length=100.	Inch.	Inch.
Zinc 8 + 1 tin, slightly hammered	$\frac{1}{372}$	0.26917	0.322	0.0179
White solder: tin 1, lead 2.	$\frac{1}{399}$	0.25053	0.301	0.0167
Tin, grain	$\frac{1}{403}$	0.24833	0.298	0.0166
Tin	$\frac{1}{462}$	0.21730	0.260	0.0145
Silver	$\frac{1}{524}$	0.19075	0.229	0.0127
Speculum metal	$\frac{1}{517}$	0.19333	0.232	0.0130
Brass	$\frac{1}{532}$	0. 8782	0.225	0.0125
Copper	$\frac{1}{581}$	0.17220	0.207	0.0115
Gun metal: 16 copper, 1 tin	$\frac{1}{524}$	0.19083	0.229	0.0127
Gun metal: 8 copper, 1 tin	$\frac{1}{550}$	0.18167	0.218	0.0121
Yellow brass: rod	$\frac{1}{528}$	0.18930	0.227	0.0126
" " trough form	$\frac{1}{528}$	0.18945	0.227	0.0126
Gold: Paris standard, annealed	$\frac{1}{661}$	0.15153	0.181	0.0101
Gold: Paris standard, unannealed	$\frac{1}{648}$	0.15516	0.186	0.0103
Bismuth	$\frac{1}{719}$	0.13917	0.167	0.00928
Iron, forged	$\frac{1}{819}$	0.12204	0.146	0.00814
" wire	$\frac{1}{812}$	0.12350	0.148	0.00823
Steel rod, 5 feet long	$\frac{1}{874}$	0.11450	0.137	0.00763
" " tempered	$\frac{1}{807}$	0.12396	0.149	0.00826
" " not tempered	$\frac{1}{926}$	0.10792	0.130	0.00719
Cast iron rod, 5 feet long	$\frac{1}{901}$	0.11100	0.133	0.00740
Antimony	$\frac{1}{923}$	0.10833	0.130	0.00722
Palladium	$\frac{1}{1000}$	0.10000	0.120	0.00667
Platinum	$\frac{1}{1167}$	0.8570	0.103	0.00571
From 0° to 300° C. (32° to 572° F.)				
Copper { 0° to 100° C.	$\frac{1}{583}$	0.17182	0.206	0.0115
Copper { 0° to 300° C.	$\frac{1}{531}$	0.18832	0.226	0.00418
Iron { 0° to 100° C.	$\frac{1}{846}$	0.11821	0.142	0.00788
Iron { 0° to 300° C.	$\frac{1}{681}$	0.14684	0.176	0.00326
Platinum { 0° to 100° C.	$\frac{1}{1103}$	0.08842	0.106	0.00589
Platinum { 0° to 300° C.	$\frac{1}{1089}$	0.09183	0.111	0.00204
ICE.				0.0333

GLASS.	Expansion between 32° and 212° F. in common fractions.	Expansion between 32° and 212° F. in a length = 100.	Expansion between 32° and 212° F. in a length of 10 feet.	Expansion for 1° F. in a length of 100 feet.
		L'gth=100.	Inch.	Inch.
Flint glass	$\frac{1}{1248}$	0.08117	0.974	0.00541
French glass, with lead	$\frac{1}{1147}$	0.08720	0.105	0.00581
Glass tube, without lead	$\frac{1}{1090}$	0.09175	0.110	0.00612
Glass of St. Gobain	$\frac{1}{1122}$	0.08909	0.107	0.00594
Barometer tubes (Smeaton)	$\frac{1}{1175}$	0.08333	0.100	0.00555
Glass tube (Roy)	$\frac{1}{1289}$	0.07755	0.0931	0.00517
Glass rod, solid (Roy)	$\frac{1}{1237}$	0.08083	0.0970	0.00539
Glass (Dulong and Petit)	$\frac{1}{1161}$	0.08613	0.103	0.00574
" (0° to 100° C.)	$\frac{1}{1032}$	0.09484	0.114	0.00632
" (0° to 300° C.)	$\frac{1}{987}$	0.10108	0.121	0.00674

STONES.

NAME.	Initial temperature.	Final temperature.	Expansion in a length = 100.	Expansion for 1° F. in a length of 100 feet.
			Length=100.	Inch.
Granite	45° F.	220° F.	0.2916	0.0200
"	45	100	0.0416	0.00908
Clay-slate	46	87	0.0416	0.0122
"	46	104	0.0693	0.0143
York paving	46	95	0.1695	0.0415
Micaceous sandstone	52	200	0.1736	0.0141
" "	52	200	0.1041	0.00844
" "	52	150	0.0832	0.0102
" "	52	100	0.0520	0.01300
" "	45	100	0.0416	0.00908
" "	45	260	0.1458	0.00814
Carrara marble	32	212	0.0849	0.00566
Sost "	32	212	0.0568	0.00380
Stock brick	52	260	0.2500	0.00144

Frigorific Mixtures.—For the production of intense cold, mixtures of various salts and acids in various proportions with water are very effective. But more intense degrees of cold are produced with snow and ice. The annexed table contains the ordinary mixtures for the artificial production of cold, known as freezing mixtures. The first part of the table comprises mixtures of salts and acids with each other and with water; the second part, mixtures of salts and acids with snow or ice.

The blanks in the third column of the table indicate that the thermometer sinks to the degrees named in the second column, but never lower, whatever may be the initial temperature of the material when mixed.

The vessels containing the mixture should be cooled before the elements are put into them.

If the materials of the mixtures enumerated in the first part of the table be mixed at a higher temperature than that given in the table, namely 50° F., the fall of temperature is greater. Thus, if the most powerful of these mixtures, No. 11, be made at the temperature 80° F., it will sink the thermometer to + 2°, making a fall of 78 degrees as against 71 degrees in the table.

The third part of the table contains frigorific mixtures partly selected from the other parts, and combined so as to extend the cold to the extreme degree, — 91° F. The materials should be cooled previously to being mixed to the initial temperature, by mixtures taken from previous parts of the table.

FRIGORIFIC MIXTURES.

FIRST PART.—*Proportional Mixtures of Salts and Acids with Water.*

MIXTURES.		Fall of temperature.	Degrees of cold produced
		Fahrenheit.	Fahr.
1. Nitrate of ammonia	1	from + 50° to + 4°	46°
Water	1		
2. Muriate of ammonia	5	from + 50° to + 10°	40
Nitrate of potash	5		
Water	16		
3. Muriate of ammonia	5	from + 50° to + 4°	46
Nitrate of potash	5		
Sulphate of soda	8		
Water	16		
4. Sulphate of soda	3	from + 50° to — 3°	53
Dilute nitric acid	2		
5. Nitrate of ammonia	1	from + 50° to — 7°	57
Carbonate of soda	1		
Water	1		
6. Phosphate of soda	9	from + 50° to — 12°	62
Dilute nitric acid	4		
7. Sulphate of soda	8	from + 50° to 0°	50
Hydrochloric acid	5		
8. Sulphate of soda	5	from + 50° to + 3°	47
Dilute sulphuric acid	4		
9. Sulphate of soda	6	from + 50° to — 10°	60
Muriate of ammonia	4		
Nitrate of potash	2		
Dilute nitric acid	4		
10. Sulphate of soda	6	from + 50° to — 14°	64
Nitrate of ammonia	5		
Dilute nitric acid	4		
11. Phosphate of soda	9	from + 50 to — 21°	71
Nitrate of ammonia	6		
Dilute nitric acid	4		

SECOND PART.—*Proportional Mixtures of Salts and Acids with Snow or Ice.*

MIXTURES.		Fall of temperature.	Degrees of cold produced
		Fahrenheit.	Fahr.
12. Muriate of soda (common salt)	1	from any temp. to — 5°	—
Snow or pounded ice	2		
13. Muriate of soda	2	do. do. to — 12°	—
Muriate of ammonia	1		
Snow or pounded ice	5		
14. Muriate of soda	10	do. do. to — 18°	—
Muriate of ammonia	5		
Nitrate of potash	5		
Snow or pounded ice	24		
15. Muriate of soda	5	do. do. to — 25°	—
Nitrate of ammonia	5		
Snow or pounded ice	12		
16. Dilute sulphuric acid	2	from + 32° to — 23°	55°
Snow	3		
17. Muriatic acid	5	from + 32° to — 27°	59
Snow	8		
18. Dilute nitric acid	4	from + 32° to — 30°	62
Snow	7		
19. Muriate of lime	5	from + 32° to — 40°	72
Snow	4		
20. Crystallized muriate of lime	3	from + 32° to — 50°	82
Snow	2		
21. Potash	4	from + 32° to — 51°	83
Snow	3		

THIRD PART.—*Mixtures partly selected from the foregoing series, and combined so as to increase or extend the cold to the greatest extremes.*

MIXTURES.		Fall of temperature.	Degrees of cold produced
		Fahrenheit.	Fahr.
22. Sea salt	5	from — 5° to — 18°	13°
Muriate of ammonia, Nitrate of potash	5		
Snow or pounded ice	1		
23. Sea salt	5	from — 18° to — 25°	7
Nitrate of ammonia	5		
Snow or pounded ice	12		
24. Phosphate of soda	5	from 0° to — 34°	34
Nitrate of ammonia	3		
Dilute nitric acid	4		

THIRD PART.—*Mixtures partly selected from the foregoing series, and combined so as to increase or extend the cold to the greatest extremes.*

Mixtures.		Fall of temperature.	Degrees of cold produced
		Fahrenheit.	Fahr.
25. Phosphate of soda Nitrate of ammonia Dilute mixed acids	3 2 4	from — 34° to — 50°	16°
26. Snow Dilute nitric acid	3 2	from 0° to — 46°	46
27. Snow Dilute sulphuric acid Dilute nitric acid	8 3 3	from — 10° to — 56°	46
28. Snow Dilute sulphuric acid	1 1	from — 10° to — 60°	50
29. Snow Muriate of lime	3 4	from + 20° to — 48°	68
30. Snow Muriate of lime	3 4	from + 10° to — 54°	64
31. Snow Muriate of lime	2 3	from — 15° to — 68°	53
32. Snow Crystallized muriate of lime	1 2	from 0° to — 66°	66
33. Snow Crystallized muriate of lime	1 3	from — 40° to — 73°	33
34. Snow Dilute sulphuric acid	8 10	from — 68° to — 91°	23

Management of Saws.

There is no tool in use that is more in demand than the saw, and there is no other implement more misused. The success of the saw-mill depends upon the saw; therefore it is essential that none but competent men should manage it. No saw should be dressed otherwise than right, that is, both sides alike, and made accurately round and in balance.

The shape of the teeth is of the utmost importance to the successful running of the saw, and yet but little attention is paid to this matter by the majority of filers. There are many different shapes used by filers in putting a saw in order, and, of course, all cannot be right.

It is well known among first-class mechanics that when a cutting tool is brought in contact with a surface that is to be removed at a certain angle, the chip is removed with less power than would otherwise be required; consequently this angle is the right one to have, and the next thing to learn is how to get this desired angle for the teeth. The following rule will serve this purpose.

To lay out the shape of the tooth, measure the distance from the eye of the saw to the point of the teeth; now measure three-fifths of the distance from the eye of the saw, and strike a circle at that distance on

the saw; then strike a straight line from this circle to the point of the teeth, which will give you the angle of the teeth, which is the main point to keep in mind in shaping them. To get the proper shape of the back of the tooth, place your dividers with one point on the point of the tooth and the other on the circle in front of the centre, with your compasses set to strike a circle the size of the saw. This will produce a thin cutting edge like a chisel or plane bit, and make the highest running saws when the right depth of teeth and proper amount of throat are given. The depth of the teeth should be half the distance from point to point of the teeth, except when they are more than 3 inches apart, in which case a depth of 1½ inches is enough.

When the teeth are too long they will spring and tremble more, and the saw will stand less feed and dodge oftener. In fitting the points of the teeth both full swag and spring set are used, but swag is preferable, especially when there is plenty of power and the teeth are swaged properly. They are then not so liable to dodge and make snaky lumber. But any saw that has not been properly hammered and given the right tension will buckle and dodge, however well it is dressed. The time has come when it is essential for a filer to thoroughly understand the hammering of saws, as that constitutes one of the most important parts of the business, and, indeed, if he lacks this knowledge he cannot be regarded as a first-class filer.

As to the proper speed of a saw, 700 revolutions per minute will give the best results, yet many saws run much slower, and a great many somewhat faster.

The feed which a saw should have depends upon the amount of power to drive it. The feed should be regulated so as to give the saw proper speed. If the speed is too slow, the feed should be decreased until the right speed is attained, and if too fast, or if there is a surplus of steam, more feed should be given.

As to the size of saws there is but little difference in the power required to drive them. A 60-inch saw is perhaps to be preferred, but saws from 48 to 72 inches are used with success. The gage should be from six to ten, but a thin saw is preferable, as it will run lighter. It is, however, more difficult to keep a thin saw in order, and eight or nine gage is preferable for general work.

WRINKLES FOR ENGINEERS.

STEAM.

Pressure of steam is termed its tension or elastic force, and is expressed in pounds per square inch.

Temperature of steam is the number of degrees of heat indicated by a thermometer immersed in it.

Density of steam is the weight of a unit of its volume compared with that of water.

Relative volume, the space occupied by a given weight of volume of steam, compared with the weight or volume of the water that produced it.

Steam in contact with water is at its *maximum density.*

Under the pressure of the atmosphere alone the temperature of water cannot be raised above its boiling point.

Upon every square inch of the earth's surface there rests $14\frac{7}{10}$ lbs., in round numbers 15 lbs. of air.

If exposed to the open air at the level of the sea the boiling point

of ordinary fresh water is 212° F., and at this temperature it is rapidly converted into vapor or steam which has an elastic force equal to that of the atmosphere.

Steam is not half as heavy as air: the specific gravity of air being 1.0000, and that of steam but 0.4883.

13.817 cubic feet of air weigh 1 pound.

26.36 cubic feet of steam, at atmospheric pressure, weigh 1 pound. Haswell gives 27.222 cubic feet; others a little more.

About 65 cubic feet of air furnish 1 pound of oxygen.

An apartment 8 feet high, 12 feet wide and 13 feet long contains about 100 lbs. of air; and a room 40 feet square and 18 feet high contains about a ton.

Steam, of atmospheric pressure, will flow into a vacuum at the speed of about 1550 feet in a second of time.

The temperature of steam, as indicated by the thermometer, does not show the whole amount of heat contained in it. The heat indicated by a thermometer is called *sensible* heat; while the heat which cannot be detected by the thermometer is called *latent* heat.

If boiling water has absorbed 212° of heat to bring it into that condition, it will require an addition of 966° to make it into steam of atmospheric pressure. These 966 degrees of heat which were added have become latent. The steam weighs just the same as the water from which it was formed—1 cubic foot of water having made 1669 cubic feet of steam, commonly computed at 1700 cubic feet of steam.

A cubic inch of water, evaporated under the ordinary atmospheric pressure (15 lbs. on the square inch), is converted into 1700 cubic inches of steam, or, in a unit of very nearly 1 cubic foot, and it exerts a mechanical force equal to the raising of 2120.14 pounds 1 foot high.

SENSIBLE HEAT OF STEAM.

Pounds. Pressure.	Temperature.	Pounds. Pressure.	Temperature.
0	212 degrees.	50	298 degrees.
5	228 "	60	307.5 "
10	240.1 "	70	316.1 "
20	259.3 "	80	324.1 "
30	274.4 "	90	331.3 "
40	287.1 "	100	338 "

By the term saturated steam is meant not as some think *wet steam*, but simply dry steam as it is formed in contact with water.

Flow of Steam through pipes and from a given orifice.—The approximate weight of any fluid which will flow in one minute through any given pipe with a given head or pressure may be found by the following formula:

$$W = 300 \sqrt{\frac{\frac{D\,(P_1 - P_2)\,d^5}{3.6}}{L\,(1 + d)}}$$

in which W = weight in lbs. avoirdupois, d = diameter in inches, D = density or weight per cubic foot; p, the initial pressure, p_2 pressure at end of pipe, and L = length in feet.

The following table gives, approximately, the weight of steam per minute which will flow from various initial pressures, with one pound

loss of pressure through straight, smooth pipes, each having a length of 240 times its own diameter:

TABLE OF FLOW OF STEAM THROUGH PIPES.

Initial pressure by gauge. lbs. per sq. in.	Diameter of Pipe in inches. Length of each = 240 diameters.						
	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	4
	Weight of steam per minute in pounds, with one pound loss of pressure.						
1	1.16	2.07	5.7	10.27	15.45	25.38	46.85
10	1.44	2.57	7.1	12.72	19.15	31.45	58.05
20	1.70	3.02	8.3	14.94	22.49	36.94	68.20
30	1.91	3.40	9.4	16.84	25.35	41.63	76.84
40	2.10	3.74	10.3	18.51	27.87	45.77	84.49
50	2.27	4.04	11.2	20.01	30.13	49.48	91.34
60	2.43	4.32	11.9	21.38	32.19	52.87	97.60
70	2.57	4.58	12.6	22.65	34.10	56.00	103.37
80	2.71	4.82	13.3	23.82	35.87	58.91	108.74
90	2.83	5.04	13.9	24.92	37.52	61.62	113.74
100	2.95	5.25	14.5	25.96	39.07	64.18	118.47
120	3.16	5.63	15.5	27.85	41.93	68.87	127.12
150	3.45	6.14	17.0	30.37	45.72	75.09	138.61

Initial pressure by gauge. lbs. per sq. in.	Diameter of Pipe in inches. Length of each = 240 diameters.						
	5	6	8	10	12	15	18
	Weight of steam per minute in pounds, with one pound loss of pressure.						
1	77.3	115.9	211.4	341.0	502.4	804	1177
10	95.8	143.6	262.0	422.8	622.5	996	1458
20	112.6	168.7	307.5	496.5	731.3	1170	1713
30	126.9	190.1	346.8	559.8	824.1	1318	1930
40	139.5	209.0	381.3	615.3	906.0	1450	2122
50	150.8	226.0	412.2	665.0	979.5	1567	2294
60	161.1	241.5	440.5	710.6	1046.7	1675	2451
70	170.7	255.8	466.5	752.7	1108.5	1774	2596
80	179.5	269.0	490.7	791.7	1166.1	1866	2731
90	187.8	281.4	513.3	828.1	1219.8	1951	2856
100	195.6	293.1	534.6	862.6	1270.1	2032	2973
120	209.9	314.5	573.7	925.6	1363.3	2181	3195
150	228.8	343.0	625.5	1009.2	1486.5	2378	3481

For sizes of pipe below six-inch, the flow is calculated from the *actual* areas of "standard" pipe of such nominal diameters.

For horse-power, multiply the figures in the table by 2. For any other loss of pressure, multiply by the square root of the given loss. For any other length of pipe, divide 240 by the given length expressed in diameters, and multiply the figures in the table by the square root of this quotient, which will give the flow for one pound loss of pressure. Conversely, dividing the given length by 240 will give the loss of pressure for the flow given in the table.

The loss of head due to getting up the velocity, to the friction of the steam entering the pipe, and passing elbows and valves, will reduce the flow given in the tables. The resistance at the opening, and that at a globe valve, are each about the same as that for a length of pipe equal to 114 diameters divided by a number represented by 1 + (3.6 ÷ diameter). For the sizes of pipes given in the table, these corresponding lengths are:

¾	1	1½	2	2½	3	4	5	6	8	10	12	15	18
20	25	34	41	47	52	60	66	71	79	84	88	92	95

The resistance at an elbow is equal to ⅔ that of a globe valve. The equivalents for opening for elbows, and for valves, must be added in each instance to the actual length of pipe. Thus a four-inch pipe, 120 diameters (40 feet) long, with a globe valve and three elbows, would be equivalent to $120 + 60 + (3 \times 40) = 360$ diameters long; and $360 \div 240 = 1\frac{1}{2}$. It would therefore have 1½ pounds loss of pressure at the flow given in the table, or deliver ($1 \div \sqrt{1\frac{1}{2}} = .816$), 81.6 per cent. of the steam into the same (1 lb.) loss of pressure.

Flow of Steam from a given orifice.—Steam of any pressure flowing through an opening into any other pressure, less than three-fifths of the initial, has practically a constant velocity, 888 feet per second, or a little over ten miles per minute; hence the amount discharged in pounds is proportionate to the weight or density of the steam. To ascertain the pounds, avoirdupois, discharged per minute, multiply the area of opening in inches, by 370 times the weight per cubic foot of the steam.

Or the quantity discharged per minute may be approximately found by Rankine's formula. $W = 6\, a\, p \div 7$, in which W = weight in pounds, a = area, in square inches, and p = absolute pressure. The theoretical flow requires to be multiplied by $k = 0.93$, for a short pipe, 0.63 for a thin opening, as in a plate, or a safety valve.

Where the steam flows into a pressure more than ⅗ the pressure in the boiler:

$W = 1.9\, a\, k \sqrt{(p - \delta)\, \delta}$; in which δ = difference in pressure between the two sides, in pounds per square inch, and a, p and k as above.

To reduce to horse-power, multiply by 2.

Where a given horse-power is required to flow through a given opening, to determine the necessary difference in pressure.

$$\delta = \frac{p}{2} - \sqrt{\frac{p^2}{4} - \frac{H.P.^2}{14\, a^2 k}}$$

Air as a Standard.

The mean pressure of the atmosphere at the level of the sea is equal

to 14.7 lbs. per square inch, or 2116.4 lbs. per square foot. This is called one atmosphere of pressure. The following are measures of pressures:

One atmosphere of pressure:—1. A column of air at 32° F., 27.801 feet or about 5¼ miles high, of uniform density equal to that of air at the level of the sea. 2. A column of mercury at 32° F., 29.922 inches or 76 centimetres high; nearly 30 inches. At 62° F. the height is 30 inches. 3. A column of water at 62° F. 33.947 feet high; nearly 34 feet.

A pressure of 1 lb. per square inch:—1. A column of air at 32° F., 1891 feet high, of uniform density as above. 2. A column of mercury at 32° F., 2.035 inches high. At 62° F. the height is 2.04 inches. 3. A column of water at 62° F., 2.31 feet or 27.72 inches high.

A pressure of 1 lb. per square foot:—1. A column of air at 32° F., 13.13 feet high, of uniform density as above:—2. A column of mercury at 32° F., 0.0141 inch high. At 62° F. the height is 0.01417. 3. A column of water at 62° F., 0.1925 inch high.

The density or weight of one cubic foot of pure air, under a pressure of one atmosphere, or 14.7 lbs. per square inch, is,

at 32° F. = 0.080728 lb. or 1.29 ounce or 565.1 grains
at 62° F. = 0.076097 " " 1.217 " " 532.7 "

The weight of a litre of pure air, under one atmosphere, at 32° F., is 19.955 grains.

The weight of air compared with that of water at three notable temperatures, and at 52.3° under one atmosphere, is as follows:

Weight of water at 32° F.	773.2	times the weight of air at 32° F.
" " " " 39.1° "	773.27	" " " " " " " "
" " " " 62° "	772.4	" " " " " " " "
" " " " 62° "	819.4	" " " " " " 62° F.
" " " " 52.3° "	820	" " " " " " " "

The volume of 1 lb. of air at 32° F. and under one atmospheric pressure is 12.387 cubic feet. The volume, at 62° F., is 13.141 cubic feet.

The specific heat of air at constant pressure is 0.2377, and at constant volume, 0.1688, that of water being = 1.

WATER.

A gallon of water (U. S. standard) weighs 8⅓ pounds and contains 231 cubic inches.

A cubic foot of water weighs 62½ lbs. and contains 1.728 cubic inches, or 7½ gallons.

Doubling the pipe increases its capacity four times.

Friction of liquids in pipes increases as the square of the velocity.

Each nominal horse-power of boilers requires 30 to 35 pounds of water per hour.

To find the area of a piston, square the diameter and multiply by 0.7854.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by 0.434.

To find the capacity of a cylinder in gallons: multiply the area in inches by the length of stroke in inches which will give the total number of cubic inches. Divide this amount by 231 (which is the cubical contents of a gallon in inches) and the product is the capacity in gallons.

Ordinary speed to run pumps is 100 feet of piston per minute.

To find the quantity of water elevated in one minute running at 100 feet of piston per minute: square the diameter of water cylinder in inches and multiply by 4. Example: Capacity of a five-inch cylinder is desired. The square of the diameter (5 inches) is 25, which multiplied by 4 gives 100, which is gallons per minute (approximately).

To find the horse-power necessary to elevate water to a given height, multiply the total weight of column of water in pounds by the velocity per minute in feet and divide the product by 33,000 (an allowance of 25 per cent. should be added for friction, etc.).

Pressure of Water.—A pressure of 1 lb. per square inch is exerted by a column of water 2.3093 feet or 27.71 inches high, at 62° F., and a pressure of one atmosphere, or 14.7 lbs. per square inch, is exerted by a column of water 33.947 feet high at 62° F.

A column of water at 62° F., one foot high, presses on the base with a force of 0.433 lbs., or 6.928 ounces per square inch.

A column of 100 feet high presses with a force of 43⅓ lbs. per square inch.

A column of water one inch high presses on the base with a force of 0.5773 ounce per square inch, or 5.196 lbs. per square foot.

A column of water one mile deep, weighing 62.4 lbs. per cubic foot, presses on the base with a force of about one ton per square inch (fresh water exactly 48 lbs. more, sea water exactly 107.5 lbs. more.)

Water is hardly compressible under pressure. Experiments appear to show that for each atmosphere of pressure it is condensed 47½ millionths of its bulk.

Sea-Water.—One cubic foot of average sea-water at 62° F. weighs 64 lbs., and the weight of fresh water is to that of sea-water as 39 to 40, or as 1 to 1.026.

Thirty-five cubic feet of sea-water weigh one ton.

One cubic yard of sea-water weighs 15½ cwt. nearly (8 lbs. less).

One cubic metre of sea-water weighs fully one ton (20 lbs. more).

Average sea-water is composed as follows:

	Per 100 parts.	Per 100 parts.
Chloride of sodium (common salt)	2.50	
Sulphuret of magnesium	0.53	
Chloride of magnesium	0.33	
Carbonate of lime, Carbonate of magnesia	0.02	
Sulphate of lime	0.01	
Solid matter, say		3.40
Water		96.60
		100.00

showing that sea-water contains $\frac{1}{30}$ part of its weight of solid matter in solution.

According to Réclus, the mean specific gravity of sea-water is 1.028. In the Mediterranean Sea it is 1.029; in the Black Sea, 1.016. The mean quantity of salts or solid matter, in solution, is 3.44 per cent., three-fourths of which is common salt. In the Red Sea the water contains 4.3 per cent.; in the Baltic Sea, 5 per cent; and at Cronstadt, 2 per cent.

Ice and Snow.

One cubic foot of ice at 32° F. weighs 57.50 lbs.

One pound of ice at 32° F. has a volume of 0.174 cubic foot or 30.067 cubic inches.

The volume of water at 32° F. is to that of ice at 32° F. as 1.000 to 1.0855; the expansion in passing into the solid state being above 8½ per cent. of the volume of water.

The specific density of ice is 0.922, that of water at 62° F. being = 1.

The melting point of ice is 32° F. or 0° C., under the ordinary atmospheric pressure of 14.7 lbs. per square inch. Under greater pressure the melting point is lower, being at the rate of 0.133° F. for each additional atmosphere of pressure.

The specific heat of ice is 0.504, that of water being = 1.

One cubic foot of fresh snow weighs 5.20 lbs. Snow has 12 times the bulk of water, and its specific gravity is 0.833.

To Cool a Hot Journal.—Quite an ingenious way of cooling a journal that cannot be stopped is to hang a short, endless belt on the shaft next to the box, and let the lower part of it run in cold water. The turning of the shaft carries the belt slowly around, bringing fresh cold water continually in contact with the heated shaft, and without spilling or spattering a drop of water.

Gross Power from Piston Areas.—Look in the following table, in the square corresponding to the mean effective pressure and piston speed of your engine, and you have a number which, multiplied by the piston area, gives the gross horse-power:

*Multipliers for Various Speeds and Pressures.**

Pounds mean effective pressure.	Lineal piston speeds in feet per minute.						
	300 .0090909	**350** .01060606	**400** .0121212	**450** .01363636	**500** .015515	**550** .0166667	**600** .0181818
10	.090909	.106061	.121212	.136364	.151515	.166667	.181818
15	.136364	.159090	.181818	.204545	.241818	.255814	.272727
20	.181818	.212111	.242424	.272727	.303030	.333333	.363636
25	.227273	.265165	.303030	.340909	.378788	.416666	.454545
30	.272727	.318181	.363636	.409090	.454545	.500000	.545554
35	.318182	.371212	.424242	.477272	.530303	.583333	.636364
40	.363636	.424242	.484848	.545454	.606061	.666666	.727273
45	.409091	.477272	.545455	.613636	.701819	.750000	.828283
50	.454545	.530303	.606061	.681818	.757576	.833333	.909091
55	.500000	.583333	.666667	.750000	.833333	.916666	1.000000
60	.545455	.636363	.727373	.818181	.909091	1.000000	1.090909

* As the gross horse-power is equal to the product of the mean effective pressure, the piston area and piston speed divided by 33000, these multipliers are got by dividing 33000 into the product of the mean effective pressure by the piston speed.

To get a multiplier from any other mean effective pressure, multiply that mean effective pressure by the small figures in the column headings.

To get multipliers for any other lineal piston speed, multiply the mean effective pressure in the table by the small figures under them.

Pump Capacity, how to calculate.—Multiply the volume displaced by the water piston at each stroke in cubic inches by the number of strokes per hour. This will give the volume per hour which can be reduced to gallons by dividing by 231. The amount actually pumped may fall off from this on account of the pump failing to fill, or may slightly exceed it on account of momentum given to the column.

TABLE OF NUMBER OF GALLONS DISCHARGED PER MINUTE BY A SINGLE ACTING PUMP OF A GIVEN DIAMETER AND STROKE, AT TEN STROKES PER MINUTE.

Diameter of Pump Barrel in Inches.	Length of Stroke in Inches.								
	1.	2.	3.	4.	5.	6.	7.	8.	9.
1	.028	.056	......	.112	.140	.168	.196	.224	.252
1¼	.044	.088	.132	.176	.220	.264	.308	.352	.396
1½	.063	.126	.189	.252	.315	.378	.441	.504	.567
1¾	.086	.172	.258	.344	.430	.516	.602	.688	.774
2	.113	.226	.339	.452	.565	.678	.791	.904	1.017
2½	.176	.352	.528	.704	.880	1.056	1.232	1.408	1.574
3	.254	.508	.762	1.016	1.270	1.524	1.77	2.032	2.286
3½	.346	.692	1.038	1.384	1.73	2.07	2.42	2.76	3.11
4	.452	.91	1.35	1.82	2.26	2.71	3.16	3.61	4.06
4½	.572	1.14	1.71	2.29	2.86	3.43	4.00	4.57	5.14
5	.7	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3
5½	.8	1.70	2.55	3.40	4.25	5.10	5.95	6.8	7.65
6	1.01	2.02	3.03	4.04	5.05	6.06	7.07	8.08	9.09
7	1.38	2.77	4.15	5.54	6.92	8.31	9.69	11.08	12.06
8	1.80	3.61	5.42	7.23	9.04	10.85	12.66	14.47	16.28
9	2.289	4.57	6.86	9.15	11.44	13.73	16.02	18.31	20.60
10	2.827	5.45	8.43	11.30	14.13	16.96	19.78	22.61	25.44
12	4.068	8.13	12.20	16.27	20.34	24.40	28.47	32.54	36.61
15	6.361	12.72	19.08	25.44	31.80	38.16	44.52	50.88	57.24
18	9.158	18.31	27.47	36.63	45.79	54.94	64.10	73.26	82.42
20	11.307	22.61	33.92	45.23	56.53	67.84	79.15	90.45	101.76
24	16.282	32.56	48.84	65.12	81.41	99.69	113.97	130.25	146.53

TABLE OF NUMBER OF GALLONS DISCHARGED PER MINUTE BY A SINGLE ACTING PUMP OF A GIVEN DIAMETER AND STROKE, AT TEN STROKES PER MINUTE.

DIAMETER OF PUMP BARREL IN INCHES.	LENGTH OF STROKE IN INCHES.							
	10.	**12.**	**14.**	**15.**	**16.**	**18.**	**20.**	**24.**
1	.28	.336	.392	.420	.448	.504	.56	.672
1¼	.44	.528	.616	.660	.704	.792	.88	1.056
1½	63.	.756	.882	.945	1.088	1.134	1.26	1.572
1¾	.86	1.032	1.204	1.29	1.376	1.548	1.72	2.064
2	1.13	1.356	1.582	1.695	1.808	2.034	2.26	2.712
2½	1.76	2.112	2.464	2.64	2.816	3.148	3.52	4.224
3	2.54	3.048	3.55	3.81	4.06	4.57	5.08	6.09
3½	3.46	4.15	4.84	5.19	5.52	6.22	6.92	8.30
4	4.52	5.42	6.32	6.73	7.22	8.12	9.04	10.84
4½	5.72	6.86	8.0	8.57	9.54	10.28	11.44	13.72
5	7.0	8.4	9.8	10.5	11.2	12.6	14.0	16.8
5½	8.5	10.2	11.9	12.75	13.6	15.3	17.0	20.4
6	10.1	12.12	14.14	15.15	16.16	18.18	20.20	24.24
7	13.85	16.62	19.38	20.77	22.16	24.12	27.7	33.24
8	18.09	21.7	25.32	27.13	28.94	32.56	36.18	42.14
9	22.89	27.46	32.04	34.33	36.62	41.2	45.78	54.92
10	28.27	33.92	39.56	42.40	45.22	50.88	56.54	67.84
12	40.68	48.8	56.94	61.02	65.08	73.22	81.36	97.6
15	63.61	76.32	89.04	95.41	101.76	114.48	127.22	152.64
18	91.58	109.88	128.2	137.37	146.52	164.84	183.16	219.76
20	113.07	135.68	158.3	169.6	180.9	203.5	226.14	271.36
24	162.82	195.4	227.9	244.23	260.5	293.0	325.6	390.8

Cleansing Surface Condensers.—On the steam side the greasy deposit is best removed by filling with a solution of caustic soda and boil by letting steam in. The scale deposit on the water side is best removed by scraping. When the tubes are removable they can be soaked in kerosene, which both removes the oily deposit and softens the scale.

Management of Steam Boilers.—In Grimshaw's "Miller, Millwright and Mill-Furnisher," the following capital set of rules is given: 1. *Condition of the water.*—The first duty of an engineer, when he enters his boiler-room in the morning, is to ascertain how many gages of water there are in his boiler. Never unbank or replenish the fire until this is done. Accidents have occurred, and many boilers have been entirely ruined from neglect of this precaution. 2. *Low water.*—In case of low water, immediately cover the fire with ashes, or if no ashes are on hand, use fresh coal. Do not turn on the feed under any circumstances, nor tamper with nor open the safety valve. Let the steam outlets remain as they are. 3. *In case of foaming*, close the throttle, and keep closed long enough to show the true level of water. If that level is sufficiently high, feeding and blowing will usually suffice to correct the evil. In case of violent foaming caused by dirty water, or change of fresh to salt, or *vice versa*, in addition to the action above stated, check the draft and cover the fire with fresh coal. 4. *Leaks.*—When leaks are discovered they should be repaired as soon as possible. 5. *Blowing-off.*—Blow down under a pressure not exceeding 20 lbs., at least once in two weeks; every Saturday night would be better. In case the feed becomes muddy, blow out six or eight inches every day. Where surface blow-cocks are used, they should be often opened for a few moments at a time. 6. *Filling up the boiler.*—After blowing down, allow the boiler to cool before filling up again. Cold water pumped into hot boilers is very injurious from sudden contraction. 7. *Exterior of boiler.*—Care should be taken that no water comes in contact with the exterior of the boiler, either from leaky joints or from other causes. 8. *Removing deposit and sediment.*—In tubular boilers the hand-holes should often be opened, and all collections removed from over the fire. Also, when boilers are fed in front and blown off through the same pipe, the collection of mud or sediment in the rear end should often be removed. 9. *Safety valve.*—Raise the safety valves cautiously and frequently, as they are liable to become fast in their seats and useless for their intended purpose. 10. *Safety valve and pressure gage.*—Should the gage at any time indicate the limit of pressure, see that the safety valves are blowing off. 11. *Gage cocks and glass gages.*—Keep the gage cocks clear and in constant use. Glass gages should not be relied on altogether. 12. *Blisters.*—When a blister appears there must be no delay in having it carefully examined and trimmed or patched, as the case may require. 13. *Clean sheets.*—Particular care should be taken to keep the sheets and parts of the boiler exposed to the fire perfectly clean; also all tubes, flues and connections well swept. This is particularly necessary where wood or soft coal is used as fuel. 14. *General care of boilers and connections.*—Under all circumstances keep the gage cocks, etc., clean and in good order, and things generally in and about the engine and boiler-room in a neat condition. He closes with the following *Pertinent Questions:* How long since you were inside of your boiler? Were any of the braces slack? Were any of the pins out of the braces?

Did all the braces ring alike? Did not some of them sound like a fiddle-string? Did you notice any scale on flues or crown-sheet? If you did when do you intend to remove it? Have you noticed any evidence of bulging in the fire-box-plates? Do you know of any leaky socket bolts? Are any of the flange joints leaking? Will your safety-valve blow off of itself, or does it stick a little sometimes? Are there any globe valves between the safety-valve and the boiler? They should be taken out *at once* if there are. Are there any defective plates about your boiler? Is the boiler so set that you can inspect every part of it when necessary? If not, how can you tell in what condition the plates are? Are not some of the lower courses of tubes or flues in your boiler choked with soot or ashes? Do you absolutely know of your own knowledge that your boiler is in safe and economical working order? or do you merely suppose it is? These are questions of great importance. With a steam boiler, it is most emphatically true, that the price of safety is eternal vigilance. He who assumes its charge, takes on himself a grave responsibility, and the slightest lapse into carelessness on his part may result in disaster to life and property.

How Boiler Plates are Proved.—This is done by placing a piece of Bessemer steel 10 inches long in the testing machine. Gradually the surface scales off in the middle to become smaller in area and somewhat elongated, till at last it breaks with a sharp snap at a breaking strain of about 28 tons to the square inch, the reduction of area being 51 per cent. and the elongation 23 per cent.

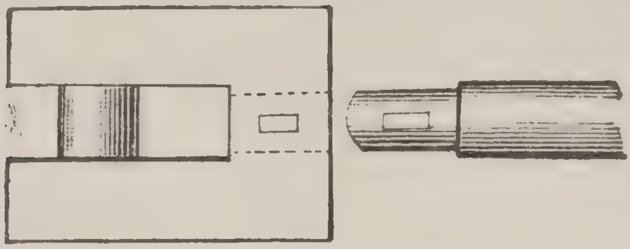
Zinc in Boilers.—The action of zinc upon lime scale is said to be to keep it pulverulent and prevent it from forming into a hard, compact mass. Zinc is used, however, more for the prevention of corrosion than of scaling. When two metals are used in contact, a galvanic couple is established and the metal which is electro-positive is rapidly corroded. This action takes place where brass or copper tubes and fittings are used in connection with iron and frequently results from the use of different kinds of iron in the same boiler. To prevent it zinc is placed in the boiler in contact with the plates, and, being electro-positive, is corroded instead of the iron and may be renewed as required.

Rule for Finding the Pressure it Takes to Lift Simply the Lever and Valve of an Ordinary Safety Valve.—First find on the lever the position of its centre of gravity. This you may do by balancing the lever on a knife's edge. The vertical line drawn on the lever from the knife's edge will pass through the centre of gravity. Measure the distance from this line on the lever to the centre of the fulcrum; multiply this distance in inches by the weight in pounds of the lever and divide the product by the distance in inches from the centre of the valve to the centre of the fulcrum; the quotient will be the total pressure required to lift the valve and lever. To find the pressure per square inch on the valve divide the pressure just found by the area in square inches of the valve; the quotient will be the pressure per square inch.

Engine-room Repairs.—The following hints are given by W. E. Crane in "Power-Steam:" It not infrequently happens that some fits become loose, like a piston-rod in the cross-head, as shown in Fig. 59. In this case the key draws the rod in up to the shoulder, as the key binds

in the key-way of the cross-head, and still the rod is loose and causes a disagreeable knocking, besides being liable to cause trouble.

Fig. 59.



To remedy this take a piece of writing paper and wrap one thickness around the end of the rod that goes into the cross-head; put the rod in and draw it up with the key. Unless it is an uncommonly loose fit it will be found to be all right.

Where a piston is found to be loose on a rod and the same is drawn on with a key or a nut, the same remedy will apply and save the expense of a new rod in both cases.

Good tough paper is better in these cases than brass, as it is much easier fitted and packs solid, while brass under a given pressure draws. The paper should be thoroughly dry, and where it is put in so solid moisture cannot reach it. Inside the cylinder, however, the heat will gradually burn it, and in such a position it might have to be replaced.

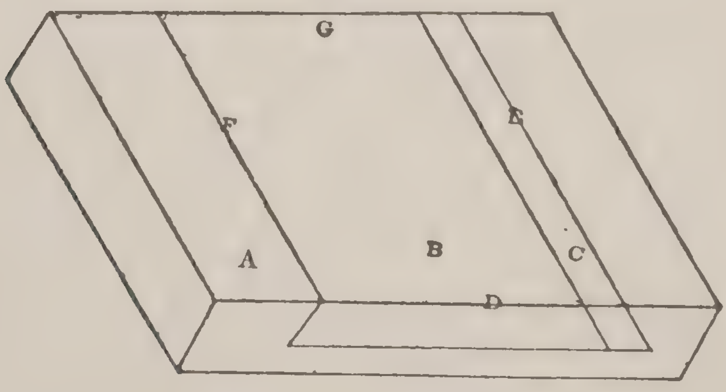
Paper will do the work where packing is required that is drawn up tight so that no friction comes on it. It also comes handy in setting machinery on foundations where packing up is required.

There are cases where holes have to be filled, like a sand or blowhole in castings. Sometimes these break out after a machine has been running.

A cheap and effective way of filling these is to dig them out the longest at the bottom, as a dentist digs out the cavity of a tooth for filling; build a little pocket of putty around it with a suitable support and fill it with babbitt metal; then trim it down level.

A manner of filling a hole with iron is shown in Fig. 60. A piece

Fig. 60.



can be dove-tailed in on this plan in a hole that is in such a position that the piece inserted cannot be slipped in "endways," but must be

dropped in from the top. The cut simply shows a block A, with the dove-tail piece B and the key C.

If a hole be cut out of a plain surface on the lines D, E, F, C, and the piece B be made narrow enough to fall between the lines E, F, and then the key C driven, it is all dove-tailed in solid shape and cannot get out unless the key C gets loose.

This is a nice job to do, but if well done and the key made a driving fit it will stay. To make it surer it might be well to secure the key C with one or more screws or with pins.

Butt-Splicing of Vulcanized Rubber Belting.—Fig. 61 illustrates the manner of butt-splicing vulcanized rubber belting. The

Fig. 61.

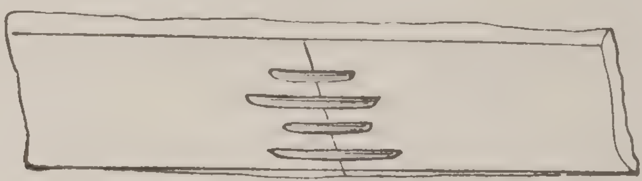
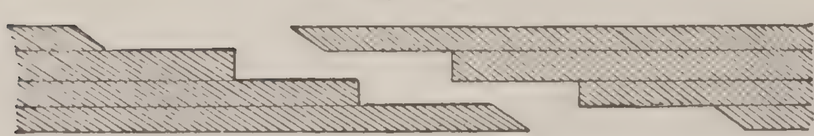


Fig. 62.



belt to be adjusted to the pulley (depending upon the thickness of the belt) should be cut shorter than the distance around the pulleys by $\frac{1}{8}$ to $\frac{1}{4}$ of an inch for every foot when measured with a tape or string drawn tight. For narrow belts make two rows of holes in each end, thus obtaining a double hold; butt the ends together and lace with lacing leather. For wide heavy belts a rivetted lap-splice, fully illustrated in Figs. 62 and 63, is recommended.

Fig. 63.

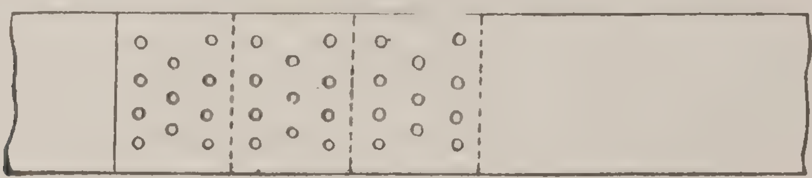
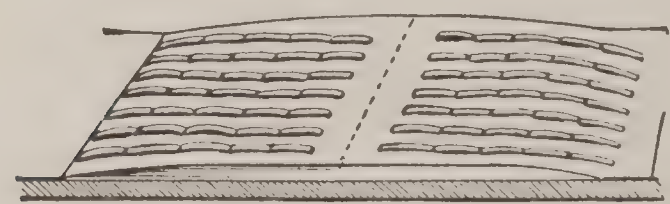


Fig. 64.



In Fig. 64 is shown a back splice intended for wide belts where the rivetted lap-splice is not used. To make this splice butt the ends and, in addition, sew or rivet a piece of rubber belting on the back to

strengthen the joint, equal in length to about one-half the width of the belt.

THE STEAM-ENGINE INDICATOR.*

The function of the indicator is to automatically trace out on a paper a diagram that will graphically represent the pressure of the steam in the cylinder of the engine to which it is attached, with all its variations during both forward and return strokes of the piston. It enables those who use or have charge of steam-engines to ascertain the condition of the parts of the engine subject to the direct action of the steam and to what advantage the steam is applied; whether the valves are properly designed and accurately set, and if the steam passages or ports are of the proper size to receive and discharge the steam in time to produce the best effect; what pressure of steam there is upon the piston at every position in the cylinder, as well as its average during the stroke; what is the value of the vacuum acting upon the piston of a condensing engine in all its positions in the cylinder, and what is its average; whether the exhaust passages from the cylinder are sufficiently large to give free exit to the steam, and if not, what percentage of power is lost in forcibly expelling it; the actual consumption of steam in giving motion to the shafting and mill-work, the paddle-wheel, or screw propeller; and also what power is required to move the machinery or any part of it.

In manufacturing establishments where power is let, it will show how much each tenant consumes; and in large establishments, where friction of shafting and machinery forms a large proportion of the resistance offered, it guides in the selection of proper lubricants.

Indicator cards are of great value as they demonstrate the initial, mean effective, and terminal pressures, the back pressure, the cushion, whether by compression or lead; the point of cut-off, and the relative economy of different engines aside from leakage and condensation. It may be applied not only to steam-engines but those driven by compressed air, or any vapor or fluid, as well as to cylinders of air-pumps, air-compressors, blast-engines, etc. The diagram produced is the joint production of two movements, viz., a vertical movement of the marking point due to the pressure of the steam acting on the piston of the instrument, in opposition to the force of a spring of known strength, and a horizontal movement of the paper, as the drum on which it is placed makes partial rotations to and fro coincident with the movement of the piston. Hence, when the pencil is held in contact with the paper during one revolution of the engine, both will arrive at the point from which they started at the same moment, and a closed figure will be the result, except when a great change in the load and pressure occurs during the stroke in which the diagram was taken.

The value of indicator cards is that they show what proportion of the boiler pressure is contained in the cylinder; how early in the stroke the highest pressure is reached; how well it is maintained; at what point and at what pressure the steam is cut off; whether it is cut off sharply, or in what degree it is wire-drawn; at what point, and at what pressure it is released; whether it is freely discharged, or what proportion of it (in excess of the atmosphere or vacuum in the condenser, according as the engine is condensing or non-condensing)

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* From "Engineer's Handy-Book" by Stephen Roper; and "Practical Steam-Engineer's Guide" by Emory Edwards.

remains to exert a counter or back pressure; whether before the commencement of the stroke there is any compression of the vapor remaining in the cylinder, and if so, at what point in the stroke it commences, and to how high a pressure it rises. The foregoing particulars can only be learned by observation, though a scale corresponding with the spring used is needed to measure the pressures, and to locate the exact events in the stroke. The points to be observed in estimating diagrams are, the mean or average pressure; the total mean, or the mean effective pressure; the indicated horse-power, I. H. P., and the theoretical water consumption. The indicator shows the pressure at each and every point in the stroke; to represent this faithfully is its sole office. The causes which determine the form of the figure must be determined by the engineer.

Technical Terms used in connection with the employment of the Indicator.

Adiabatic literally means no transmission. As applied to an expansion curve, it means that it correctly represents at all points the pressure due both to the volume and the temperature, just as if no transmission of heat to or from it had taken place.

Admission. This term is applied to the induction of the steam into the cylinder when the valve opens at the commencement of the stroke.

The term *Asymptote* means a line which approaches nearer and nearer to some curve, but which, though infinitely extended, would never meet it. The clearance and vacuum lines of a diagram are asymptotes of a true expansion curve.

The letter *B* at the end of a diagram means that that end was taken from the bottom end of the cylinder.

A B or *A b a* is understood to stand for above atmosphere, and *B A* or *B l a*, below atmosphere.

Compression is a term used to express the distance through which the piston moves in the cylinder after the exhaust has closed. Compression takes place between the piston and cylinder-head at the end of each stroke; and the distance from the end of the cylinder at which it takes place depends on the amount of lap on the valve.

Cushion means the resistance offered on the opposite side of the piston induced by the steam shut up in the cylinder.

Cylinder Efficiency. This term is used to designate the amount of work performed in the cylinder of a steam-engine for a given pressure.

Clearance expresses the extent of the space which exists between the piston, the cylinder-head and the valve-face at each end of the stroke.

Displacement. This term is applied to the cubic contents. or the volume of water, steam, or air displaced by the piston during one stroke. It may be found by multiplying the area of the piston in inches by its stroke in inches. The product will be its displacement in cubic inches.

Duty. This term is understood to mean the efficiency of steam-engines, or the number of pounds that an engine is capable of raising one foot high per second with an expenditure or consumption of one hundred pounds of coal.

Flexure means bending or curving. The point of flexure in a diagram is the point at which the cut-off closes and the expansion

curve begins. The point of contrary flexure is the point at which the line changes its direction by curving outward and afterwards inward.

H. P. cyl. stands for high-pressure cylinder.

H. P. means horse-power, which, when applied to the steam-engine, means 33,000 lbs. raised one foot high; or 150 lbs. raised 220 feet high; or 550 lbs. raised one foot high in one second.

The term *Hyperbola* means a plane figure which is formed by cutting a portion from a cone by a plane, parallel to its axis or to any plane within the cone, which passes through the cone's vertex. The curve of the hyperbola is such that the difference between the distances of any point in it from two given points is always equal to a given right line.

The term *Isothermal* means uniform or same temperature. As applied to an expansion curve, it means that such a curve represents correctly the expansion or compression of the steam when the temperature is uniform.

L. P. cyl. means low-pressure cylinder.

The term *Ordinates* means the vertical lines drawn across diagrams to facilitate the calculation of their power.

Parallelism. This term is generally employed where two or more straight lines might be extended indefinitely, without any tendency to approach or diverge from one another.

Release. This term is understood to mean exhaust. *Residuary* exhaust is that which follows the first release of the terminal pressure. The term *negative* exhaust is sometimes used, though not generally understood in its literal sense. It means compression or cushion, and absolutely amounts to the same thing, as it is merely an early product of the exhaust, for the purpose of retaining a portion of steam in the cylinder as the crank approaches the centre of the stroke.

Rev. or *Rev's* is understood to mean revolutions per minute, though *rspm* is sometimes used.

I. H. P. means indicated horse-power. It means the number of H. P. of energy shown by the diagram of an engine, as found by multiplying together the area of the piston in square inches, its speed in feet per minute, and the mean effective pressure shown, and dividing the product by 33,000.

N. H. P. means net horse-power, which is the I. H. P. minus the friction of the engine.

The term *Initial Pressure* is generally understood to mean the pressure represented in the cylinder between the opening of the steam-valve and the closing of the cut-off. More properly speaking, it is the pressure represented in the cylinder at the commencement of the stroke, as the pressure frequently falls considerably before the closing of the cut-off.

M. E. P. means Mean Effective Pressure. It is simply the amount by which the average impelling pressure exceeds the average resisting or counter-pressure. The *M. E. P.* on the piston of a steam-engine is the measure or exponent of the work performed.

The term *Terminal Pressure* means the pressure at which the steam is exhausted from the cylinder, and may be said to be the exponent of the consumption of water by the engine.

The term *Pipe Diagram* is applied to diagrams taken from the steam-pipe for the purpose of determining how much of the pressure of the steam in the pipe is lost in passing through the steam-ports to the cylinder.

The term *Scale* means the number of pounds of steam per square inch (acting on the piston of an engine) represented by each inch of vertical height on the diagram. Thus a forty-pound scale means that each inch on the diagram represents forty pounds of steam per square inch, and so on.

The term *Spring* means the spring which is employed on the piston of the instrument in order to resist the pressure of the steam and the vacuum. The following table will give the limit of pressure in the cylinder to which each spring may be subjected. The length of each spring given in the third column is such that each of them would be extended (when subjected to a perfect vacuum) to a length of $2\frac{7}{16}$ inches, which is the approximate length which would carry the pencil to the lower limit of the range of movement above given.

Scale of spring.	Limit of cylinder-pressure above atmosphere.	Length of spring.
15 pounds per inch.	25 pounds.	2.192 inches = nearly $2\frac{1}{5}$ inches.
20 " " "	38 "	2.255 " = a little above $2\frac{1}{4}$ ins.
30 " " "	64 "	2.315 " = " " $2\frac{3}{10}$ ins. or nearer $2\frac{5}{16}$ ins.
40 " " "	90 "	2.345 " = nearly $2\frac{7}{20}$ inches.
60 " " "	143 "	2.376 " = a little over $2\frac{3}{8}$ ins.
80 " " "	195 "	2.391 " = a little above $2\frac{3}{8}$ ins.

To find the corresponding limit for grades not given multiply the total range of movement, 2.625 inches, by the scale of the spring, and deduct the pressure of the atmosphere.

Example: Suppose it is desired to find the limit of pressure for a 50-pound spring: $50 \times 2.625 - 14.7 = 116.55$.

The term *String* means the aggregate length of the ordinates of an indicator diagram.

The letter T on a diagram denotes that that end was taken from the top end of a cylinder.

The term *Undulating* means rising and falling, wavy.

Wire-drawing. This term is applied to the common method of regulating the flow of steam from the boiler to the cylinder, by throttling or forcing the steam to ooze through some small or intricate device, such as the governor-valve, thus tending to destroy its elastic force.

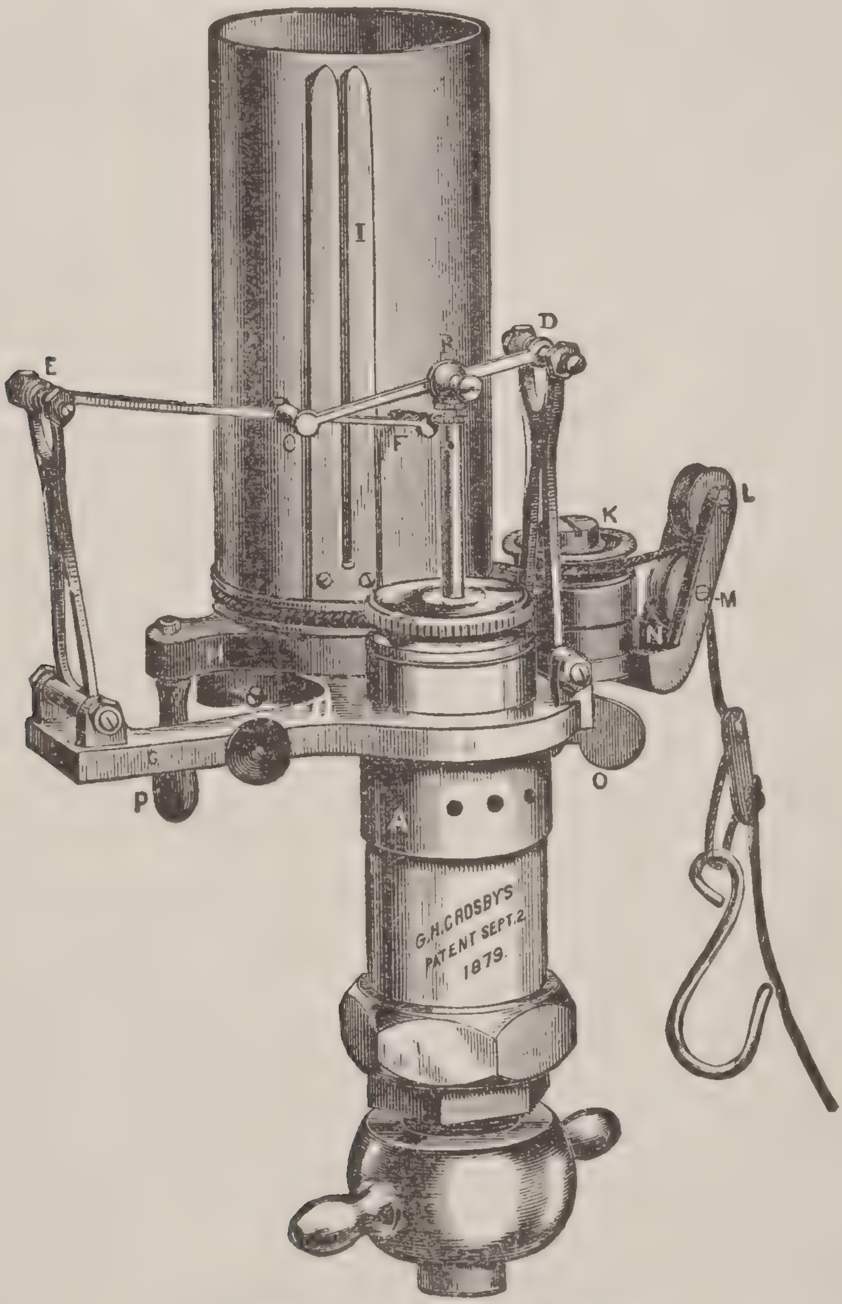
Zero. This term, when applied to indicator diagrams, means a vacuum.

The Crosby Indicator.—The principle and action of indicators are so simple that it will only be necessary to give the following cut and description of this instrument to readily appreciate the advantages accruing from its use.

A is a case or jacket enclosing a cylinder, into which a piston is

nicely fitted to move without friction; to the upper side of this piston is attached a steel helical spring, the upper end of which is fastened to the cap or head of the cylinder; to the upper end of the piston-rod B is directly jointed the short lever C D, whose short end is jointed to the head of a vibrating standard at D, and its long end is jointed to the long lever E F at the point C. The long arm of the lever E F is

Fig. 65.



THE CROSBY STEAM-ENGINE INDICATOR.

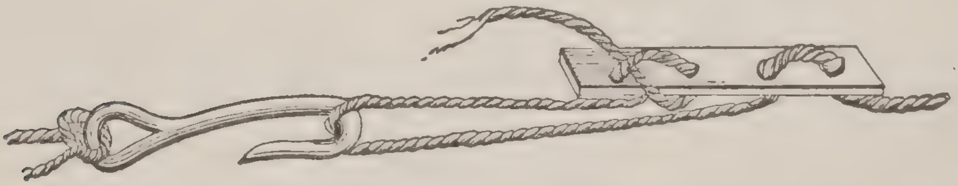
jointed at its outer extremity to a second vibrating standard at E, and to the other extremity is attached the pencil F. To the case A is permanently attached the horizontal plate G, at one end of which is jointed a corresponding plate H, situated above the former and carrying the revolving drum covered by the paper cylinder I. To this drum is at-

tached a cord, wound around a groove at its base and carried by the guide-wheel K, between the two extra guide wheels L and M, the guide-wheels L and M are attached to the arm N, which swivels around a point in line with the axis of guide-wheel K and is held in its proper position by the thumb-nut O. The drum carrying the paper cylinder I is rotated in one direction by the tension on the cord, and in the reverse direction by the reaction of a spring enclosed therein; the tension upon this spring may be adjusted to suit by the thumb-nut at the open end of the drum. The plate H carrying the drum and paper cylinder is held away from the pencil F by a spring situated between the plates H and G, directly in the line with the axis of the drum, until the operator desires to take a diagram. By pressing upon the handle P the paper cylinder is moved forward, and the pencil comes in contact with the paper. Immediately upon removing this pressure the paper cylinder automatically assumes its former position. Two adjustable stops determine the amount of this motion and regulate the force with which the pencil presses upon the paper, a hair line being attainable without friction. The bushing which carries the pencil is bored to receive a graphite or metallic wire, and is supplied with means for holding it in any position required. The piston-rod is bored at each end almost half its length, leaving a thin partition or stop in the centre; the upper chamber is used as a reservoir for a lubricant and is provided with pin-holes close to the partition to allow the oil to flow out and down and so lubricate the rod and piston; the lower chamber allows the steam to enter and warm the lubricant, causing it to assume a more limpid form and flow freely in cold weather. The piston-rod is thus made lighter without weakening it materially. A minute portion of felt placed at the bottom of the reservoir will prevent the oil from flowing too readily. It can be filled at the cross-head with a few drops of oil by using a common pressure oiler with a very small nozzle. To adjust the pencil to the proper position for springs of different scales the head of the piston-rod is provided with a screw-threaded sleeve and lock-nut, by means of which the pencil may be made to assume any desired height. If it is wished the guide-wheels, etc., may be removed to the opposite end of the plates H and G. The use of a revolving drum for transmitting motion to the paper having been demonstrated to be the best means for the purpose, it has been adopted, the only prerequisites being sufficient strength of spring and inelasticity of cord to overcome the momentum of the reciprocating parts. In any other devices, such as require a connecting-rod, there is imparted to the latter a tremulous and excessive motion, caused by its length and weight running at high speed when connected with a vibrating arm, which is transmitted to the lines of the diagram, thus producing error.

How to Attach the Indicator.—The indicator should be connected as closely to the cylinder of the engine as possible, as pressure is lost by the use of pipes. The connection may be made by drilling the cylinder or its heads; but care should be used in drilling the cylinder that the piston does not cover the hole at the end of the stroke. By allowing a small quantity of steam to enter the cylinder as the drill begins to go through, all chips will be blown out. No lead or putty should be used in making the connections. Keep clear of the thoroughfares, as steam passing the hole for the connection reduces the pressure in the indicator; screw the stop-cock to its place, then open it and blow steam through to clear the connections, and attach the indicator by means of

the union nut when in the best position to operate; move the adjustable guide-wheels to the best position for receiving the cord, and then connect the cord to the apparatus for transmitting the motion from the engine to the paper. The cord must be connected with some part of the engine having a movement coincident with the piston, and which would give the paper cylinder a movement of about three-fourths of a revolution; it will frequently be found necessary to erect a temporary rocker-shaft, or lever connecting with the cross-head, for reducing the motion; for a beam-engine, a point on the parallel bar, beam or beam-centre will answer. Beyond these suggestions, the ingenuity and judgment of the operator must determine what is required to produce the proper movement. Care should be taken that the cord should be so led off from the part which gives it motion that, when the engine is on half-stroke, it will be at right angles to such part; but between the first pulley and the indicator it may take any required direction. Use as few pulleys and as short a cord as possible. It is also necessary that the length of the cord be easily adjusted, and readily connected and disconnected. To meet these requirements, one end should be provided with a running loop and hook, as shown in Fig. 66. Arrange the

Fig. 66.



motion of the paper cylinder by means of the running loop, so that it shall not be checked at one end of the stroke by the stop-fixture, and thereby slacken the cord; nor at the other end by the springs for holding the paper on the cylinder coming in contact with the pencil, either of which would render the diagram useless.

How to Take a Diagram.—Remove the paper cylinder from the drum and place the paper upon it; the easiest method of doing this is to secure the two lower corners of the paper between the thumb and finger, then put the loop so made over the top of the cylinder; slip the edges under the springs and slide the whole down to the bottom, leaving it smooth and tight.

Return the cylinder to the drum; adjust the cylinder to the pencil for a hair line; open the stop-cock and allow the steam to enter; heat and expand the cylinder to give freedom of motion; then turn the T handle of the cock-plug to a horizontal position to allow of atmospheric pressure *under* the piston as well as above it; connect the cord and draw the atmospheric line; then turn the T handle to a vertical position, and press the paper cylinder up to the pencil by means of the handle *P* long enough for the engine to make one revolution. No nicety is required in this, as the adjustable stop determines the distance moved and delicacy of the lines drawn. The engine should be allowed, a short time before taking diagrams, to clear the cylinder from water and thoroughly heat it.

If it is a new indicator, allow its piston to work for a few moments before taking a diagram. After a diagram is taken, disconnect the cord by means of the hook and close the stop-cock, as continual working only wears out the instrument needlessly. Remove the paper, and

make the proper memoranda upon the back *at once;* this should at least include the following particulars, viz.: description of engine, scale or spring, diameter of cylinder and piston-rod, which end of cylinder, length of stroke, number of revolutions per minute, cubic contents of clearance and thoroughfares, pressure of steam in the boiler, and, if a condensing-engine, the vacuum indicated by the gauge. As many more particulars and circumstances should be added as can be readily ascertained, among which it is well to include the length of connecting-rod and the weight of all the reciprocating parts; to avoid mistakes designate the two ends of the cylinder as *out-end* and *crank-end.*

Diagrams.—It must always be remembered that the indicator's office is only to represent the pressure on the piston at each point of the stroke by lines circumscribed upon paper. The correct reading of these lines is left entirely to the operator. For the mere purpose of ascertaining the condition of the valves, piston, etc., it will be quite sufficient to scan the outlines of the diagram; but, if the power of the engine is required, the mean pressures upon the opposite sides of the piston must be ascertained by measurement. In using a graphite wire for marking the lines any paper susceptible of taking a fine impression from an ordinary lead-pencil will answer; but, if the metallic point is used, a paper expressly prepared for the purpose is necessary. Diagrams should be taken from both ends of the cylinder, and simultaneously, if practicable; and the mean result taken as a basis for estimating the power of the engine.

The common idea that, if the valves are properly adjusted, two diagrams thus taken must be alike is a mistake. They will, in some respects, be dissimilar from various causes, one of which is the difference in the speed of the piston at opposite ends of the stroke. There may be a difference also in the size of the thoroughfares. The extreme ends of the diagrams are produced at the exact time the engine is passing its centres. In diagrams of non-condensing engines the lower line is usually drawn slightly above the atmospheric pressure.

To Compute the Average Pressures.—Divide the diagram into a number of equal spaces by lines drawn at right angles to the atmospheric line; ten is usually sufficient, but twenty is better if great accuracy is required. A proportional divider, with a small try-square, answers every purpose.

In *non-condensing* engines, when calculating the average pressure on the steam side of the piston for the whole stroke, the mean pressure in each division or space enclosed by these lines, between the upper line (steam and expansion) and the atmospheric line, should be first ascertained. This may be done either by carefully measuring each space between the atmospheric line and the upper line of diagram by the *scale* corresponding to the spring used in the instrument, and the sum of these measurements divided by the number of spaces give the average pressure per square inch upon the working side of the piston, or average impelling pressure for the whole stroke; or, upon measuring the spaces with a *common rule,* divide their sum by the number of spaces and multiply the quotient by the number of the spring, and the result is the same. Proceed in like manner to find the average resisting pressure upon the opposite side of the piston, measuring the distance in each space between the lower line (counter-pressure and compression) and the atmospheric line; the *difference* between the average impelling pressure and the average resisting pressure gives the mean

effective pressure exerted. Should the expansion line fall below the atmospheric line, the area of the loop thus formed should be measured in like manner and deducted the same as the compression and counter-pressure. If the diagram is also divided by lines drawn parallel to the atmospheric line into equal spaces and corresponding to a certain number of pounds of pressure, say five pounds, as per scale, beginning at vacuum, the operator is enabled readily to read the general characteristics by sight. A very simple method of measuring diagrams has been suggested, which is much easier than the above and reduces liability of error. Take a narrow strip of paper which has a straight edge, place it across the diagram, and let one end of this strip come directly over the atmospheric line; then with a knife-blade or sharp pencil mark the length of the first space as determined by the steam line; then move the paper along to the next space, placing the mark made by the pencil over the atmospheric line; then make another mark at the point where it crosses the steam or expansion line, whichever it may be, being careful always to take a point on the upper line, which shall represent the mean length as nearly as possible; so proceed until the length of each space has been added to the first; then measure with a rule from the end of the paper to the last pencil mark, divide this by the number of spaces to get the average length and multiply the quotient by the number of the spring in use, and the result is the average impelling pressure per square inch. Proceed in like manner to measure the average resisting pressure, etc. Ten is the usual number of spaces used, but for exactness twenty is better.

A quicker method of ascertaining the *effective* pressure, whether in condensing or non-condensing engines, is to measure the spaces between the upper and lower lines of the diagram without regard to the atmospheric line, and then proceed in the manner above stated. This does away with separate measurements, excepting when a loop is formed in non-condensing engines.

LUBRICATING OILS.

Points to be considered when purchasing Lubricating Oils.

1. *Safety*, determined by flash and firing points, and also by its freedom from any tendency to oxidize.

2. *Body* at the temperature at which the oil has to do its duty. This is at present determined by the oil's viscosity considered with its specific gravity.

3. *Chemical action on metals.* Apart from the wear and tear caused by the use of an oil of a body too thin for the bearing it has to lubricate, much damage may be done to a bearing by lubricating it with an oil which contains, or will produce, acid, or which in some manner acts detrimentally upon the metals.

4. *Durability*, ascertained very largely by the tendency to evaporate when heated, by its attenuation under heat, and also more or less indicated by the flashing point.

5. *Freezing Point*, or the degree at which it becomes solid. This, however, need not be so particularly regarded when the oil is required for the lubrication of machinery in a room kept at an equable temperature: at the same time it is a point that should never be overlooked.

6. *Cost-price.*

Action of different Oils upon Metals.—The results of experiments by I. J. Redwood on the different kinds of metals are as follows:

Iron is least affected by seal oil, and most by tallow oil.

Brass is not affected by rape oil, slightly by seal oil and most by olive oil.

Tin is not affected by rape oil, slightly by olive oil and most by cotton-seed oil.

Lead is least affected by olive oil and most by whale oil; but whale, lard, and sperm oils all act to very nearly the same extent on lead.

Zinc seems, by the four actual weighings that were of any value, not to be acted on by mineral lubricating oil, slightly by lard oil and most by tallow oil.

Copper is not affected by mineral lubricating oil, slightly by sperm oil and most by tallow oil.

Mineral lubricating oil has no action on zinc and copper, acts slightly on brass, and most on lead.

Olive oil acts least on tin and most on copper.

Lard oil acts least on zinc and most on copper.

Cotton-seed oil acts least on lead and most on tin.

Sperm oil acts least on brass and most on zinc.

Whale oil has no action on tin, acts slightly on brass and most on lead.

Seal oil acts least on brass and most on copper.

Points to be considered in judging Hydro-carbon Oils.

1. *Color.* Should not exhibit great florescence, though they should always possess some, when observed in a reflected light. Should be perfectly clear and free from cloudiness. The latter may indicate, 1, water, 2, an excess of paraffine. Should the cloudiness result from cause 2, it will disappear upon heating the oil.

2. *Odor.* Little or no odor; what little there is should be only that which is characteristic of petroleum.

3. *Cold test.* Should not solidify at any temperature over 32° F.

4. *Freedom from acid and alkali.* Should be quite free from acid and alkali. These may be present through imperfect manipulation in refining.

Wash a sample of oil with about half its bulk of distilled water, draw the water off, and add a few drops of alcoholic solution of phenolpthalein; if these turn a red color then the presence of alkali is indicated. To detect acid, dip a strip of litmus paper into the water. The change in the color of the paper will denote the presence of acid.

5. *Saponification.* Should not saponify, when treated with an alkali.

6. *Action of sulphuric acid.* Sulphuric acid added should give a yellowish brown tint only. Should it give a dark brown or black color, with a large increase of temperature, an inferior, or an oil loaded with resin or fat oils, is indicated.

7. *Action of air.* A thin coating on a metallic surface which is exposed to the air should maintain its consistency. It should not oxidize or become gummy, nor should become rancid or bad smelling.

8. *Evaporation.* Should not lose weight by exposure at any temperature under 200° F., and should not lose 5 per cent. of weight when exposed for 10 hours at a temperature of 212° F.

9. *Flash point.* Should never possess a flashing point of less than 350° F. for machinery and shafting oils.

The flashing point for cylinder oils should be much higher, but the requisite flashing point varies according to the condition present in the cylinders being lubricated.

When it is desired to use pure mineral hydro-carbon oils upon bearings hitherto lubricated by fish, animal or vegetable oils, or by oils in

which these descriptions named more or less appear, it will be found convenient to make the change gradually, using the following mixtures:

1st week,	1 part	pure oil	and	3	parts	of	the	old	oil.		
2d "	2 parts	"	"	"	2	"	"	"	"	"	
3d "	3 "	"	"	"	1	"	"	"	"	"	

Pure mineral oil drives out so rapidly any deposits of gum left by oils previously used that in some cases the mineral oil has been condemned for working black, whereas it was simply scouring out objectionable deposits.

It is, of course, preferable to use pure mineral oil from the commencement, but in valves and cylinders it is sometimes wise not to use the heavy cylinder oils until all the grit and dirt, too often found in new steam-pipes, have passed away. These oils, being more tenacious than tallow, are liable to hold the grit upon the wearing surfaces, thereby causing the damage sometimes complained of by engineers. As a matter of precaution it is perhaps wise to use tallow for the first week, after which oil and tallow mixed, gradually decreasing the proportion of tallow until oil only is used.

In most cases more oil is given to the valves and pistons than is actually necessary. Besides this waste of oil, much damage is caused to the India rubber valves in consequence of this practice.

Mineral hydro-carbon oils possess a quality which is of great importance to some oil users. None of the animal, vegetable or fish oils remain liquid in as cold a temperature as most brands of mineral oils. Some of these do not become solid in a temperature of 32° F. They possess a cold test of 7° under freezing point, whilst neat's-foot and similar oils become solid at about 50° F.

For the lubrication of journals or bearings exposed to the cold, the mineral is, therefore, the only oil that can be satisfactorily used.

Spontaneous Combustion.—Oxidation or the tendency to absorb oxygen from the atmosphere exists more or less in all vegetable, animal and fish oils. Hydro-carbon oils are free from it. The oils which possess this property *most largely* are not used for lubrication. Oxidation entails risk of fire from spontaneous combustion. An insurance expert states that all persons using fish oils, lard oils and other animal fats, as well as vegetable oils, run a risk of spontaneous combustion, but he shows that the danger is avoidable, or else can be completely guarded against, by the mixture of mineral oils with the animal, fish or vegetable oils. For instance, he gives the proportion at 33 to 40 per cent. of mineral with lard oil, 25 per cent. with sperm oil, but will not stipulate any proportion for cotton-seed oil, as he claims that a mixture of 75 per cent. of mineral oil with it will not save it from spontaneous combustion. Adulterated oils are considered very dangerous, and the highest recommendation is given to mineral oils which are now generally used by the woolen and cotton-mills for lubrication of all light bearings, and by this means the danger of spontaneous combustion has been almost entirely removed.

On the other hand, some experts assert that fires have been caused entirely owing to the spontaneous combustion of oils contained in mixed oils. If this be the case, it probably arose from the use of very inferior mineral oil—that is, mineral oil possessing a very low flash point, which when exposed to a high temperature evaporated, leaving the other oils contained in the mixture without the necessary proportion of mineral oils, without which spontaneous combustion would ensue.

Some of the insurance companies in the United States have given considerable attention to this question of spontaneous combustion, and the Associated Mutual Insurance Companies of Boston made some experiments upon cotton waste, saturated with different oils, and then enclosed in a heated chamber. It was found that the temperature of the cotton waste, oiled with pure lard oil, reached in four hours 428° F., whilst that which had been oiled with neat's-foot oil reached 446° F. in six hours. In half an hour after each ball of oiled waste was taken out from the receptacle in which they had been exposed to these heats, they were a glowing mass, which a slight breath of air caused to burst into flames.

Similar balls of cotton waste, saturated with a mixture of 50 per cent. neat's-foot oil and 50 per cent. mineral hydro-carbon; with 67 per cent. neat's-foot oil and 33 per cent. mineral hydro-carbon; with 75 per cent. neat's-foot oil and 25 per cent. mineral hydro-carbon, were also made. The temperature of the first after being in the heated chamber seven hours was only 214° F.; the temperature of the second and third, after being exposed for 7½ hours, did not exceed 214° F., and when taken out none of them showed signs of charring. It is possible that when an oil, such as lard or neat's-foot, is exposed to the heat of a room and the heat and friction of a bearing, a larger proportion of mineral oil would be necessary, in order to prevent undue risk from spontaneous combustion. The two oils most liable to cause fires from this cause are cotton-seed and olive.

When a mixed oil has been improperly blended, or when through cold the component oils have become separated, and the oil user has unknowingly been lubricating with almost or quite pure oils, the danger from spontaneous combustion may be incurred.

COMPARATIVE TESTS OF THE VISCOSITY OF DIFFERENT OILS.

(The viscosity of sperm oil being taken as 100.)

	Sp. gravity at 60° F.	Sp. gravity at 70° F.	Viscosity at 70° F.	Viscosity at 110° F.
Sperm oil	.875	.854	100	50
Super filtered olive oil	.915	.894	211	93
American animal oil (sometimes sold as neat's-foot)	.915	.892	257	109
Lard oil	.915	.890	218	93
Rape oil, natural	.915	.894	257	113
" " blown	......	......	too thick	nearly 700
Castor oil, best	.960	.945	too thick	651
American mineral hydro-carbon	.925	.910	348	103
American mineral hydro-carbon	.915	.896	218	82
English and American mineral hydro-carbon	.910	.890	153	57
American mineral	.885	.862	153	28
" "	.860	.843	118	50
Scotch mineral	.885	.....	......	28
English mineral	.865	.850	159	62
" "	.860	.840	128	51

FLASHING POINTS OF LUBRICATING OILS GENERALLY IN USE.

	Degrees F.		Degrees F.
Sperm oil	520 to 530	English cottonseed oil.	575 to 585
Olive oil	550 to 570	American " "	over 600
Lard oil	575 to 590	Rape oil	570 to 580
Animal oil	525 to 535	Best English mineral	340 to 400
Castor oil	540 to 545	Best American mineral	340 to 400
		Scotch mineral	300 to 350

COMPARATIVE VALUES OF LUBRICATING OILS

(Taking pure Southern Sperm Oil at 100).

Fish oils:—	Southern sperm oil	100	Animal oils:—	Lard, Winter	64
	Arctic sperm oil.	55		" Summer	61
	Whale, best	44	Seed oils:—	Rape	44
	Shark	33		Cottonseed, best	44
	Modorous seal	44		" English	40
	Cod	44	Hydro-carbon oils:—	Resin	22
Nut oils:—	Ground nut	44		" pale	28
Olive oils:—	Malaga, best	70		Best Scotch, .885*	9
	Seville, "	70		Common " .885	7
	Gallipoli, "	68		Bloomless, .885	20
	Neapolitan, "	66		American, .910	20
	Mogodore, "	63		" .925, red	21
	Smyrna, "	61		" .925, pale	30
	Tunis, "	59		" .860	21
Animal oils:—	Neat's-foot, English, pure,	90 to 100		" bloomless .850	22
	Animal, American best	66		English, .910, best	20
				" .860, best	25

Note.—The proportionate values indicated above must necessarily vary with the constant fluctuations of the market. *Spec. gravity.

Simple Test of Kerosene Oil.—Take an ordinary pint tin cup. Fill it within an inch of the top with water warmed to 120° F. Pour on this water 3 or 4 tablespoonfuls of the oil to be tested. Stir the oil and water together, and wait a short time, say a minute or two, for the oil to collect on the top. Try the thermometer again, and if the temperature is more than 1 degree from 120° F., add a little cold or hot water, as the case may be, so as to bring the temperature to within 1 degree of 120° F. Then stir again and give time, as before, for the oil to come to the top. Now apply a burning match or lighted taper on a level with the top of the cup, say within half an inch of the oil. If within one second no flash occurs, the oil is reasonably safe; otherwise it is unsafe. Purchase 4 or 5 gallons of oil at a time, and apply this test at each purchase.

CONDITIONS GOVERNING THE PRODUCTION OF DIFFERENT GRADES OF PIG IRON.

In Lederbur's "Handbuch der Eisenhuettenkunde" the conditions upon which the grade of iron is dependent are given as follows:

First. Upon the chemical composition of the individual ores. A high manganese pig cannot be produced from an ore low in manganese, or a low phosporous pig from phosphoric iron.

Second. Upon the chemical composition of the whole mixture. Reduction of manganese is facilitated by a strongly basic condition of the slag-forming constituents of the mixture; sulphur is eliminated by a strongly basic slag. Moreover, the melting point of the slag produced depends upon its chemical composition. In general, the greater the amount of elements more difficult to reduce than iron (silicon, manganese, etc.) it is desired to reduce and cause to alloy with the iron, the higher the melting point of the slag must be.

Third. Upon the mineralogical condition of the constituents of the mixture. The temperature of formation of the slag is more important than the melting point with regard to the grade of iron produced, and depends upon the amount of silica in the slag, and the condition in which the slag-forming constituents exist. The different reducibility of different ores must also be taken into consideration. In smelting ore difficult to reduce, more iron is slagged off than when smelting easily reducible ores. It is also harder, in the first case, to produce iron high in silicon, carbon or manganese.

Fourth. Upon the temperature of the melting zone of the furnace. The reduction of manganese and silicon in large quantity requires high temperatures, so that high silicon or manganese pig cannot be produced in a furnace working cold. The temperature of the furnace depends upon the temperature of the blast, the nature of the fuel, the proportion between fuel and ore, and the heat consumption of the furnace. The latter is greater when large amounts of manganese and silicon are reduced and when smelting ores reducible with difficulty, than in the reverse case. All these conditions together cause a larger fuel consumption and the employment of a more highly heated blast, the higher in silicon or manganese the pig is desired to be.

Fifth. Upon the quantity of blast which the furnace receives in unit of time, or more correctly, upon the proportion this amount of air bears to the cubic capacity of the furnace. The more air a furnace receives the quicker the smelting proceeds and the greater the quantity of iron produced, but the more easily unreduced iron may be slagged off, and the less the amount of silicon and manganese reduced. Therefore, a furnace making white iron requires closer watching than when making gray iron or high manganese iron. By the proper mixing of several ores, or by mixing the same with suitable flux, different grades of iron may be produced from the same ores, even when the original condition of the ores appears to be more suitable for one purpose than the other. Bog ores, intimately mixed with quartz or quartzy red hematite ores, nearly always promote the production of gray iron; on the other hand, high manganese spathic ores when used to produce gray iron have a tendency to make the iron white if cooled suddenly, and this effect is still more marked if white iron or spiegel is produced. A large amount of alumina in the ore makes it more suitable for making gray than white iron, because it raises the temperature of formation and melting point of the slag. Conversely the production of gray iron is more difficult if ores low in alumina are used.

It is self-evident that in the production of a specified iron, no ore should be used from which elements detrimental to the employment for which the iron is intended might be introduced. The employment of spiegel generally requires freedom from phosphorus; this is also the case with gray pig for Bessemer use. It would be absurd to smelt phosphoric ores for this purpose. The amount of phosphorus is of small importance in foundry or ordinary white iron; the basic, Bessemer or Thomas process requires a high phosphorous pig; for this purpose phosphoric ores are employed. A large amount of manganese is detrimental to foundry iron, as it has a tendency to make it slightly harder and whiter. For making white iron it is more advantageous than detrimental. High phosphorous manganiferous ores are more suitable for the manufacture of white iron, while low manganese ores may be employed for both purposes, but are better adapted, especially if high in alumina, for gray than for white iron.

The purpose for which the ore is used must depend upon the above considerations, according to its nature.

Independent of the size of the furnace, the character of pig iron produced has a very marked influence upon the daily output.

The output of a given furnace being greatest when running on white (or high) irons, the production, when different grades of iron are made, has been found to be about as follows:

White (or high) pig iron	100 tons.
Gray (or foundry) pig iron	65 "
Spiegeleisen (10 to 12 per cent. manganese)	60 "
Spiegeleisen (high manganese)	40 "
Ferro-manganese (60 per cent. manganese)	25 "

STRENGTH AND OTHER PROPERTIES OF MATERIALS.

Composition of Cast Iron.—The following table shows the chemical composition of a number of varieties of cast iron which are distinguished by especially good mechanical properties.

Constituents.	Maximum.	Minimum.	Mean.
Fixed carbon	0.78	0.30	0.475
Silicon	1.96	1.13	1.434
Phosphorus	1.10	0.28	0.587
Sulphur	0.14	0.03	0.074
Manganese	1.51	0.58	1.037

Cast iron whose composition corresponds to the mean figures is best adapted for the manufacture of special varieties. By increasing the content of silicon it becomes softer, and by decreasing harder.

Effect of Remelting on the Strength of Cast Iron.

No. of melting.	Transverse strength 4½ feet bars 1 inch square.	Crushing strength per square inch.	Calculated tensile strength per square inch.
	Tons.	Tons.	Tons.
1	0.2187	44.0	9.502
2	0.1973	43.6	8.217
3	0.1793*	41.1	7.351*
4	0.1846	40.7*	7.697
5	0.1927	41.1	8.151
6	0.1959	41.1	8.349
7	0.2005	40.9	8.655
8	0.2192	41.1	9.847
9	0.2440	55.1	10.07
10	0.2531	57.7	10.40
11	0.2910	69.8	11.71
12	0.3090*	73.1	12.51*
13	0.2834	66.0	11.54
14	0.2700	95.9*	9.154
15	0.1657	76.7	5.366
16	0.1568	70.5	5.116
17	....	....	....
18	0.1396	88.0	4.196

Note.—Maximum and minimum results marked.*

Table of the Strength, Extensibility and Stiffness of Metals and Woods, Cast Iron being 1, *or unity.*

METALS.	Strength.	Extensibility.	Stiffness.
Iron, wrought..................	1.12	0.86	1.3
Gun metal	0.65	1.25	0.535
Brass..............	0.435	0.9	0.49
Zinc	0.365	0.5	0.76
Tin	0 182	0.75	0.25
Lead..............................	0.096	2.5	0.0385

WOODS.	Strength.	Extensibility.	Stiffness.
Oak	0.25	2.8	0.093
Ash.............................	0.23	2.6	0.089
Elm	0.21	2.9	0.073
Pine, yellow....................	0.3	2.6	0.1154
Beech	0.15	2.1	0.073
Mahogany, Honduras	0.24	2.9	0.487

Proportions and Strength of Single Riveted Joints in Wrought Iron Plates for Girder Work Only.

Thickness of plate.	Diameter of rivet holes.	Suitable pitch of rivets.	Space between rivets.	Lap of joint.	Ratio of punched to solid plate.	Breaking strain of metal between the holes in lbs. per square inch.	Strain on the solid part of plate per sq. in.	
							Lbs.	Tons.
1/8	1/4	3/4	1/2	3/4	0.667	36,898	24,611	11.00
"	5/16*	1 1/8	13/16	1	0.722	"	26,640	11.89
"	3/8	1 1/2	1 1/8	1 3/8	0.750	"	27,673	12.35
3/16	5/16	7/8	9/16	7/8	0.643	"	23,725	10.59
"	3/8	1 3/16	13/16	1 1/8	0.684	"	25,238	11.27
"	7/16*	1 1/2	1 1/16	1 3/8	0.708	"	26,124	11.66
"	1/2	1 7/8	1 3/8	1 3/4	0.733	"	27,046	12.07
1/4	3/8	15/16	9/16	7/8	0.600	"	22,139	9.88
"	7/16	1 1/4	13/16	1 1/8	0.650	"	23,984	10.71
"	1/2*	1 1/2	1	1 3/8	0.667	"	24,611	11.00
"	9/16	1 15/16	1 3/8	1 3/4	0.709	"	26,161	11.68
"	5/8	2 1/4	1 5/8	2	0.722	"	26,840	12.00
5/16	7/16	1 1/16	5/8	1	0.588	"	21,696	9.68
"	1/2	1 3/8	7/8	1 1/4	0.636	"	23,467	10.47
"	9/16*	1 5/8	1 1/16	1 1/2	0.654	"	24,131	10.77
"	5/8	2	1 3/8	1 3/4	0.687	"	25,349	11.32
3/8	9/16	1 7/16	7/8	1 1/4	0.609	"	22,471	10.00
"	5/8	1 11/16	1 1/16	1 1/2	0.630	"	23,246	10.38
"	11/16*	2	1 5/16	1 3/4	0.660	"	24,353	10.87
"	3/4	2 3/8	1 5/8	2 1/8	0.684	"	25,238	11.27
7/16	5/8	1 9/16	15/16	1 3/8	0.600	"	22,139	9.88
"	11/16	1 13/16	1 1/8	1 5/8	0.621	"	22,914	10.23
"	3/4*	2 1/8	1 3/8	1 7/8	0.649	"	23,946	10.69
"	13/16	2 3/8	1 9/16	2 1/4	0.695	"	25,644	11.45
1/2	11/16	1 11/16	1	1 1/2	0.592	"	21,844	9.75
"	3/4	1 15/16	1 3/16	1 3/4	0.613	"	22,618	10.10
"	13/16*	2 3/16	1 3/8	2	0.628	"	23,172	10.35
"	7/8	2 1/2	1 5/8	2 1/4	0.650	"	23,984	10.71

Note.—The rivet holes marked * are the most suitable for the given thickness of plate in ordinary cases.

Strength of Alloys when Pulled in the Direction of their Length.

Parts.	Parts.	Pounds.	Parts.	Parts.	Pounds.
Gold 5,	Copper 1	50,000	Silver 5,	Copper 1	48,000
Brass		45,000	" 4,	Tin 1	41,000
Copper 10,	Tin 1	32,000	Tin 10,	Antimony 1	11,000
" 8,	" 1	36,000	" 10,	Zinc 1	12,914
" 4,	" 1	35,000	" 10,	Lead 1	6,804
Bronze (gun metal)		30,000			

Ultimate Tensile Strength of Copper and its Alloys, and other Metals.

Description of Metal.	Specific gravity.	Ultimate tensile strength per square inch.
		Tons.
Copper:—Wrought	....	15
Cast	....	8.48 to 11.67
Ordinary bolts	....	16
Bolts with 1 per cent. phosphorus	8.202	7.56
" " 1 " "	8.592	16.47
" " 1.5 " "	8.876	17.13
" " 1 " "	....	19.20
" " 2 " "	8.614	20.25
" " 1 " "	....	20.34
" " 2 " "	8.580	20.41
" " 2 " "	8.615	20.27
" " 3 " "	8.422	21.38
" " 4 " "	....	22.32
Gun metal:—12 copper, 1 tin	....	12.94
11 " 1 "	....	13.71
10 " 1 "	....	14.73
9 " 1 "	....	17.00
Gun metal, average strength of good bronze.	....	14.73
Gun metal, average results of tests of specimens from bronze-guns—elastic strength, 6.56 tons	....	12.19
Gun metal—American guns:		
Gun heads	8.523	13.24
Breach squares	8.765	20.76
Small bars cast in same moulds with guns	8.584	18.76
Small bars cast separately in iron moulds	8.953	16.82
Small bars cast separately in clay moulds	8.313	11.51
Aluminium bronze, 90 copper, 1 aluminium.	....	32.67
" " " maximum	....	43.00
Tin, cast	....	2.11
" Banco	7.297	.95
Lead, cast	....	.81
" sheet	....	.86
" pipe	....	1.00
Zinc, cast	....	1.336
Soft solder, 2 tin, 1 lead	....	3.35
Brass, fine or yellow	....	8.02
" " " " 2 copper, 1 zinc	....	12.90
" tube, 62 copper, 38 zinc	....	46.00
" " 70 " 30 "	....	36.00
" wire	....	40.77
Muntz's metal, 3 copper, 2 zinc	....	22.00

Ultimate Tensile Strength of Copper and its Alloys, and other Metals.

Description of Metal.	Specific gravity.	Ultimate tensile strength per square inch.
		Tons.
Alloys of copper, zinc, iron and tin— "Sterro-metal:"		
Copper 10, iron 10, zinc 80	7.000	3.17
" 60 " 3, " 39, tin 1.5	....	24.00
" 60 " 4, " 44, " 2	....	
" cast in sand	....	19.25
" cast in iron, annealed	....	24.25
" cast in iron, forged red-hot	....	31.00
Copper 60, iron 2, zinc 37, tin 1	....	34.00
" 60, " 2, " 35, " 2	....	38.00
" 55, " 1.77, " 42.36, tin 0.83	....	
" cast	....	27.0
" forged red-hot	....	34.0
" drawn cold	....	38.0

Hardness of Woods. The relative hardness of woods is calculated by the hickory, which is the toughest. Estimating that, at 100, we get for pignut hickory, 86; white oak, 84; white ash, 77; dogwood, 74; scrub oak, 73; white hazel, 72; apple tree, 70; red oak, 69; white beech, 65; black walnut, 65; black birch, 62; yellow and black oak, 60; hard maple, 56; white elm, 56; red cedar, 56; cherry, 55; yellow pine, 53; chestnut, 52; yellow poplar, 51; butternut and white birch, 43, and white pine, 35. According to this formula woods possessing a degree of hardness equal to only about 40 per cent. or less than that of hickory should not be classed as hard woods. Such woods are, however, limited in quantity, and are not of sufficient importance to justify a classification, and the trade will continue to construe hard wood to mean everything except white pine.

Weight of Wood. One cord air-dried hickory or hard maple weighs about 4500 lbs., and is equal to about 2000 lbs. of coal; one cord air-dried white oak weighs about 3850 lbs., and is equal to about 1715 lbs. of coal. One cord air-dried beech, red-oak, or black oak weighs about 3250 lbs., and is equal to about 1450 lbs. of coal. One cord air-dried poplar (white wood), chestnut or elm weighs about 2350 lbs., and is equal to about 1050 lbs. of coal. One cord air-dried average pine weighs about 2000 lbs., and is equal to about 925 lbs. of coal.

Properties of American Woods. According to Prof. Sargent, the strongest wood in the United States is that of the nutmeg hickory of the Arkansas region, and the weakest the West Indian birch. The most elastic is the tamarak, the white or shell-bark hickory standing far below it. The least elastic and the lowest in specific gravity is the wood of the fig *ficus aurea.* The highest specific gravity, upon which in general depends value as fuel, is attained by the bluewood of Texas.

Treatment of Timber. With proper after-treatment of the wood the time of felling seems not to affect its durability. Early winter felling (December) should have the preference because less fermentable sap is then in the tree, and the timber will season with less care, more

slowly, and more evenly, and before the temperature is warm enough for fermentation to set in. If the wood is cut "in the sap," it is more liable to fermentation and to the attacks of insects, and more care is necessary in seasoning; for the rapid seasoning, due to the warm, dry atmosphere, produces an outer season coat which envelops an unseasoned interior liable to decay. When cut in the leaf it is advantageous to let the trees lie at full length until the leaves are thoroughly withered (two or three weeks) before cutting to size. With coniferous trees this is a good practice at any season, and if it can be done, all winter-felled trees should be left lying to leaf out in the spring, by which most of the sap is worked out and evaporated.

Always remove bark from felled trees to aid seasoning—but not from the standing tree. Never allow the tree to lie directly on the moist soil. If winter-felled, shape the timber to size within two weeks after felling and leave it placed on blocks—not upon the soil—in the forest, or if shaped at home place in a dry, airy—not windy—position away from sun and rain. If dried too rapidly, wood warps and splits, the cracks collect water and the timber is then easily attacked and destroyed by rot. With large logs, choking may be prevented by coating the ends with some fatty or oily substance mixed with brick-dust, or covering with a piece of linen, cloth, or even paper, or by simply shading them to lessen evaporation; cracks on the sides may be filled with tow or cotton. When piling timber, place laths or sticks of uniform size at uniform distances under each log, or post, or tie. Sufficiently thorough seasoning for most purposes is obtained in 12 to 18 months, while for special work, according to the size, from 2 to 10 years is required.

CRUSHING RESISTANCE OR COMPRESSIVE STRENGTH OF TIMBER.

(Reduced from Mr. Laslett's Data.)

NAME OF TIMBER. — Specimens: 1-inch, 2-inch, 3-inch and 4-inch cubes.	Average resistance per square inch.	NAME OF TIMBER. — Specimens: 1-inch, 2-inch, 3-inch and 4-inch cubes.	Average resistance per square inch.
	Tons.		Tons.
Oak:—English (unseasoned)	2.194	Eucalyptus:—Tewart	4.174
English (seasoned)	3.337	Mahogany	3.198
French	3.547	Iron bark	4.601
Tuscan	2.437	Blue gum	3.078
Sardinian	2.604	Ash:—English	3.109
Dantzic	3.344	Canadian	2.453
American, white	2.709	Elm:—English	2.583
" Baltimore	2.630	Rock	3.832
Teak, Moulmein	2.559	Hornbeam	3.711
Iron Wood	5.208	Fir:—Dantzic	3.102
Chow	5.621	Riga	2.342
Greenheart	6.438	Spruce	2.166
Sabicu	3.776	Larch	2.596
Mahogany:—Spanish	2.863	Cedar	2.000
Honduras	2.853	Red pine	2.537
Mexican	2.503	Yellow pine	1.877
		Pitch pine	2.885
		Kauri	2.867

TRANSVERSE AND TENSILE STRENGTH OF TIMBER. (Reduced from Mr. Laslett's data.)

The specimens for transverse strength were supported at both ends and loaded at the middle.

NAME OF TIMBER. (Specimens 2 inches square.)	Transverse strength.					Tensile strength.		
	Average specific gravity.	Deflection Span, 6 feet. Load 390 lbs.	Set.	Ultimate Deflec'n.	Breaking weight.	Average specific gravity.	Breaking weight per square inch.	
		Inches.	Inches.	Inches.	Pounds.		Pounds.	Tons.
Oak :—English,								
One side of tree......	.858	2.92	....	5.10	562	.858	3,837	1.713
Other side of tree...	.867	3.25	....	3.95	407			
English....................	.893	2.52	.117	7.71	813	.893	7,571	3.380
French	.976	1.48	.041	6.00	877	.976	8,102	3.617
"	1.082	1.58	.125	7.58	831			
Tuscan.	1.040	3.76	.113	7.66	758			
Sardinian..................	.990	2.61	.125	6.50	758			
Dantzic......................	.836	5.00	.240	6.46	474	.838	4,217	1.882
Spanish...	1.042	4.03	.250	6.62	562			
American, white.........	.983	1.92	.208	8.83	804	.969	7,021	3.143
" Baltimore...	.747	1.47	.191	7.13	723	.742	3,832	1.443
African (or teak).........	.993	2.25	.050	5.14	1,108	.971	7,052	3.148
Teak, Moulmein................	.776	1.65	.083	3.38	913	.777	3,301	1.474
"	.809	1.94	.083	6.49	843			
Iron wood, Burmah...........	1.176	.96	.033	4.25	1,273	1.176	9,656	4.311
Chow, Borneo....................	1.116	.92	.025	2.83	975	1.134	7,199	3.214
Greenheart, Guiana...........	1.150	2.15	.066	4.62	1,333	1.141	8,820	3.937
Sabicu, Cuba.....................	.917	.96	.033	3.75	1,293	.917	5,558	2.481
Mahogany, Spanish............	.769	1.208	.025	3.45	856	.765	3,791	1.692
Honduras..........	.659	1.916	.083	4.06	802	.659	2,998	1.338
Mexican...........	.678	1.125	.058	3.92	783	.655	3,427	1.530
Eucalyptus, Australia :—								
Tewart	1.169	1.27	.108	4.75	1,029	1.169	10,284	4.591

TRANSVERSE AND TENSILE STRENGTH OF TIMBER.

(Reduced from Mr. Laslett's data.)

The specimens for transverse strength were supported at both ends and loaded at the middle.

NAME OF TIMBER. (Specimens 2 inches square.)	Transverse strength.					Tensile strength.		
	Average specific gravity.	Deflection Span, 6 feet.			Breaking weight.	Average specific gravity.	Breaking weight per square inch.	
		Load 390 lbs.	Set.	Ultimate Deflec'n.				
		Inches.	Inches.	Inches.	Pounds.		Pounds.	Tons.
Eucalyptus, Mahogany........	1.010	3.21	.133	4.71	686	.996	2,940	1.312
Iron-bark.........	1.142	.94	.000	3.81	1,407	1.150	8,377	3.740
Blue gum.........	1.029	1.26	.100	4.21	712	1.049	6,048	2.700
Ash, English......................	.736	1.62	.050	8.63	862	.750	3,780	1.687
Canadian....................	.480	2.75	.125	7.37	638	.588	5,495	2.453
Beech..............................	....	....	....	....	....	.705	4,853	2.166
Elm, English......................	.558	4.90	1.300	5.29	393	.642	5,460	2.437
Rock elm, Canada..............	.748	1.75	.290	8.79	920	.748	9,182	4.100
Hornbeam, English............	....	....	....	....	....	.819	6,405	2.860
Fir, Dantzic........................	.582	1.63	.066	5.14	877	.603	3,231	1.442
Riga..........................	.541	1.29	.092	3.63	600	.553	4,051	1.808
Spruce, Canada............	.484	1.23	.055	5.19	670	.484	3,934	1.756
Larch, Russia.....................	.646	1.57	.175	4.33	626	.649	4,203	1.876
Cedar, Cuba........................	.439	2.27	.258	4.37	560	.469	2,870	1.281
Red pine, Canada................	.554	1.67	.133	4.63	653	.553	2,705	1.207
Yellow pine, Canada...........	.435	2.12	1.833	4.66	627			
" " "	.551	1.71	.714	3.39	483	.551	2,759	1.231
" " "	.552	2.09	.706	3.45	304	.552	2,259	1.008
Pitch pine, American..........	.659	1.12	.075	4.79	1,049	.659	4,666	2.083
" " "	.710	1.24	.063	4.67	930			
" " "	.538	1.42	.104	4.42	744			
Kauri pine, New Zealand....	.550	1.39	.125	4.00	719	.544	4,040	1.803

CRUSHING RESISTANCE OF COLUMNS OF WOOD.

English Oak, 3 inches square: Per square inch.

Unseasoned, 9 specimens, 8 to 16 inches high, sp. gr. .922.....1.68 tons
Seasoned, 2 " 17 and 18 " " " .778 ....2.52 "
Average of 4 specimens, 6 inches square, 12 to 36 inches high 3.68 "
" " " 9 " " 12 to 21 " " 2.85 "
One specimen, 9 × 10 inches, 24 inches high...............3.24 "
Two " 10 × 11 " 18 and 21 " " ....2.72, 2.91 "

Indian Teak:
6 inches square, specific gravity, .795............................ ......4.38 "
9 " " " " .838.......................................3.81 "

Dantzic Fir, under 30 inches high, average results:
6 inches square, specific gravity, .600.................................3.897 "
9 × 10 inches, " " .608.................................2.562 "
10 inches square, " " .660.................................1.812 "
10 " " " " .563.................................2.446 "

English Oak and Fir of considerable length in proportion to the scantling:

Length of Specimens.	English oak, 2 inches square.		English oak, 4 inches square.		Dantzic fir, 2 inches square.		Riga fir, 2 inches square.	
	Spec'c grav'y.	Crushing weight per square inch.	Spec'c grav'y.	Crushing weight per square inch.	Spec'c grav'y.	Crushing weight per square inch.	Spec'c grav'y.	Crushing weight per square inch.
Inch's.		Tons.		Tons.		Tons.		Tons.
1	.740	3.37	....	....	.756	2.72	....	2.47
2	"	3.41	....	....	.756	3.17	....	2.11
3	"	3.47	....	....	.720	2.97	....	2.88
4	"	3.50	....	....	.756	3.44	....	2.25
5	"	3.94	....	....	.669	3.44	....	2.63
6	"	3.72	....	....	.648	3.25	....	2.81
7	"	3.69	....	....	.617	3.19	....	2.78
8	"	3.63	....	....	.621	3.03	....	2.75
9	"	3.75	....	....	.720	3.03	....	2.50
10	"	slipped	....	....	.669	3.13	....	2.00
11	"	3.69	....	....	.726	2.91	....	2.44
12	.720	3.44	....	....	.774	3.00	....	2.78
15	....	....	.958	1.60	....	....	....	....
16	....	....	.972	1.58	....	....	....	....
17	....	....	.934	1.69	....	....	....	....
18	.720	2.75	.930	1.72	.636	2.88	....	2.47
19	....	....	.932	1.76	....	....	....	....
20	....	....	.972	1.76	....	....	....	....
21	....	....	.946	1.75	....	....	....	....
22	....	....	.932	1.63	....	....	....	....
23	....	....	.921	1.47	....	....	....	....
24	.720	2.63	1.003	1.88	.684	2.72	....	1.72

Strength of Stones.—To judge of the strength and durability of stones is a difficult matter. If the stone be fractured and presents, under a magnifying glass, a bright, clear, sharp surface, it is not likely to crumble from decay. Of course, samples can be tested for their crushing and tensile strengths, etc. And we can tell something of the weathering qualities by observing similar stones in old buildings; much, however, depends whether the stones come from the same part of the quarry. Another test is to weigh different samples when dry; immerse them in water for a given period, say 24 hours, then weigh them again, and the sample absorbing the least amount of water (in proportion to its original weight) is, of course, the best stone.

Another test is to soak the stone in water for 2 or 3 days and put it out to freeze; if it does not chip or crack, it will probably weather well. Chemical tests are made sometimes, such as using sulphuric acid to detect the presence of lime and magnesia; or soaking the stones in a concentrated boiling solution of sulphate of soda; the stones are then exposed to the air, when the solution crystallizes in the pores and chips off particles of the stone, acting similarly to frost. The stones are weighed before and after the tests, the one showing the least proportional weight being, of course, the better.

Fire Bricks and Their Properties.—Fire bricks are made by a process very similar to ordinary bricks. When broken they should show a compact and uniform close-grained structure, being free from stones, cracks, etc.; when struck they should emit a clear and ringing sound. The expansion of ordinary fire bricks by heating in rising from 32° to 212° F. is 0.0005, according to Rankine. All fire bricks forming the lining of a chimney shaft should be set in ground fire clay mixed with water to the consistency of mortar. The bricks are sometimes, before being laid, dipped into a liquid of creamy fire clay, and when laid in place hammered together so as to be when finished brick and brick. This method is now largely adopted, and answers admirably, especially where the temperature is high.

TENSILE STRENGTH OF STONE, BRICKS AND CEMENT.

Description of Material.	Weight per cubic foot.	Ultimate tensile strength per square inch
	lbs.	tons.
Sandstone	....	0.150
Whinstone	....	.655
Arbroath pavement	....	.563
Caithness "	....	.471
White Marble	....	.322
" "	....	.246
Flint glass rod annealed	....	1.07
Green glass rod	....	1.29
White crown glass rod	....	1.14
Thin glass globes, cohesion	....	2.23
		lbs.
Plaster of Paris	....	71
Mortar of quartzose, sand and hydraulic lime	....	136 to 85
Mortar of quartzose, sand and ordinary lime	....	51 to 21

TENSILE STRENGTH OF STONE, BRICKS AND CEMENT.

DESCRIPTION OF MATERIAL.	Weight per cubic foot.	Ultimate tensile strength per square inch.
	lbs.	tons.
Adhesion of plaster of Paris to brick or stone, average	....	50
Adhesion of bricks cemented with Portland cement 12 months old, and 1 cement to 1 sand	neat	1 to 1
Gault clay bricks, pressed; in air......	45	44
" " " " in water...	46	46
Gault clay bricks wire cut; in air......	68	43
" " " " " in water.	47	39
Gault clay bricks, perforated; in air...	108	83
" " " " in water	84	75
Stock bricks; in air........	78	63
" " in water........	96	70
Staffordshire blue brick, pressed with frog; in air	74	56
Staffordshire blue brick, pressed with frog; in water	76	37
Staffordshire blue brick, rough, without frog; in air	48	47
Staffordshire blue brick, rough, without frog; in water	40	29
Fareham red bricks; in air........	126	83
" " " in water........	123	62
Portland cement:		
Seven-day tests........	....	862—408
Average of do. per bushel 115.2 lbs.	90	385.5
Portland cement, 123 lbs. per bushel, mixed with equal weight of Thames mud:	neat cement	cement & sand
Age in water, 7 days........	363	157
" " " 1 month........	416	201
" " " 6 months........	523	284
" " " 12 months........	547	319
" " " 2 years........	600	351
" " " 4 "	583	363
" " " 7 "	590	384
Portland cement, 112 lbs. per bushel, mixed with various proportions of sand; 12 months old:		
3 sand, 1 cement........	....	241
5 " 1 "	....	214
7 " 1 "	....	163
Roman cement—averages:		
Age in water, 7 days........	....	90
" " " 1 month........	....	115
" " " 6 months........	....	210
" " " 12 "	....	286
" " " 2 years........	....	243
" " " 4 "	....	281
" " " 7 "	....	315

WEIGHT, STRENGTH, ETC., OF BUILDING STONES.

Compiled from experiments and tests by Gen. Gillmore, Prof. E. T. Cox and others, by Frank W. Vogdes.

KIND.	LOCALITY.	Position.	Crushing strength per inch.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Remarks.
	Sandstones.						
Brown	Middletown, Conn.	Bed	6,950	2.36	148.0	1–40	
"	Long Meadow, Mass.	"	14,650				Highest
"	Long Meadow, Mass.	"	8,800				Lowest
"	Little Falls, N. Y.	"	9,850	2.25	140.6	1–34	
Red	Haverstraw, N. Y.	"	4,350	2.13	133.1	1–23	
Pink	Medina, N. Y.	"	17,250	2.41	150.0	1–55	
Drab	Berea, O.	"	10,250	2.11	131.8	1–16	Mean.
	" "	"	7,250	2.2	137.5	1–24	Lowest.
Gray	Amherst, O.	"	8,250	2.19	136.9	1–19	
Drab	Vermilion, O.	"	8,250	2.16	135.3	1–19	
Red Brown	Seneca, O.	"	10.100	2.39	140.3	1–32	
	Cleveland, O.	"	7,910	2.24	140.0	1–37	
	Marblehead, O.	"	7,800	2.31	144.0	1–19	
Drab	Buena Vista, O.	"	12,500	2.19	137.0	1–20	
Purple	Fond du Lac, Wis.	"	6,250	2.22	138.8	1–22	
	Marquette, Wis.	"	7,275	2.28	142.8	1–20	
Pink	Kasota, Minn.	"	11,200	2.63	164.0	1–56	
Buff	Frontenac, Minn.	"	7,775	2.32	145.0	1–28	
	Warrensburg, Mo.	"	5,000	2.14	133.0	1–20	
	Lee Co., Iowa.	"	3,925	2.18	136.3	1–20	
	Craigleith, Scotland.	"	11,500	2.26	141.0	1–34	
	Dorchester, N. B.	"	9,200				
Brown dark	Mary's Point, N. B.	"	7,700				F. E. Kidder's test.
	Limestones.						
	North River blue flagging N. Y.	"	22,420	2.72	170.3	1–217	Gov. test Rock Isl.

KIND.	LOCALITY.	Position.	Crushing strength per inch.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Remarks.
	Limestones. Glens' Falls, N. Y.	Bed	11,475	2.70	168.8		Gov. test Rock Isl.
	Glens' Falls, N. Y.	Edge	10,750	"	"		
	Lake Champlain, N. Y.	Bed	25,000	2.75	172.0		
	Lake Champlain, N. Y.	Edge	21,500	"	"		
North River	Kingston, N. Y.	Bed	13,900	2.69	168.2		
	Garrison station, N. Y.	"	18,500	2.63	163.5		
Blue	Williamsville, N. Y.	"	12,300	2.64	165.0		
White	Marblehill, O.	"	11,400	2.40	150.0	1–33	
Oolitic	Bedford, Ind.	"	11,750		148.0	1–28	
"	Bloomington, Ind.	"	13,750		138.0	1–43	
"	Ellettsville, Ind.	"	12,625		152.0	1–41	
"	Ellettsville, Ind.	"	13,500		142.0	1–28	
"	Corydon, Ind.	"	10,250		150.0	1–27	
Silicious	Putnamville, Ind.	"	11,750		166.0	1–170	
Magnesian	Deputy, Ind.	"	15,750		165.0	1–156	
"	St. Paul, Ind., "Flatrock"	"	16,000		168.29	1–336	
"	Joliet, Ill.	"	12,775	2.54	158.8	1–51	
"	Joliet, Ill.	"	16,900	2.6	162.5	1–139	
"	Joliet, Ill.	"	14,650	2.54	158.8	1–91	
"	Joliet, Ill.	"	8,656	2.61	163.1	1–35	
"	Lemont, Ill.	"	13,264	2.64	165.0	1–89	
"	Athens, Ill.	"	15,125	2.51	157.1	1–28	
"	Athens, Ill.	"	9,692	2.4	160.5	1–32	
"	Nauvoo, Ill.	"	8,583	2.67	166.8	1–297	Pure limestone.
"	Hancock Co., Ill.	"	8,500	2.46	154.3	1–40	Gov. test Rock Isl.
"	Sterling, Ill.	"	10,500				
"	Bardstown, Ky.	"	15,500	2.67	167.0	1–80	
	Lime Island, Mich.	"	18,000	2.5	156.3	1–76	

Kind.	Locality.	Position.	Crushing strength per inch.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Remarks.
	Limestones.						
	Marquette, Mich.	Bed	8,000	2.34	146.0	1–23	Gov. test Rock Isl.
	Canton, Mo.	"	8,000	2.34	146.0	1–22	
	Billingsville, Mo.	"	7,000	2.32	145.0	1–23	
	Big Sturgeon Bay, Wis.	"	19,000	2.76	173.0	1–400	
	Caen, France.	"	3,500	1.9	118.8	1–19	
	Marbles.						
	Dorset, Vt.	Edge	8,670	2.68	167.8		
	Sutherland Falls, Vt.	"	11,280		180.0		Test by F. E. Kidder
	West Chester Co., N. Y.	Bed	12,950	2.87	179.0		
	Montgomery Co., Pa.	"	8,950				
	Quincy, Ill.	"	9,687	2.57	160.0	1–180	
	North Bay, Wis.	"	20,000	2.80	175.0		
	North Bay, Wis.	Edge	13,700	"	"		
	Italian.	Bed	8,950	2.7	168.7		
	Granites.						
	Fox & Dix Isl., Me.	"	15,000	2.63	165.3	None	
	Hewits' Isl., Me.	"	14,700	2.63	164.5	"	
	Hurricane Isl., Me.	"	14,425	2.67	166.9		
	Hurricane Isl., Me.	Edge	14,937	"	"		
	Keene, N. H.	Bed	12,875	2.66	166.6	1–300	
Dark	Quincy, Mass.	"	18,250	2.65	165.6	None	
Light	Quincy, Mass.	"	14,750	2.69	168.1	"	
	Cape Ann, Mass.	"	19,500				
	Fall River, Mass.	"	15,937	2.64	165.0	1–216	
	Fall River, Mass.	Edge	9,250	"	"	"	
	Rockport, Mass.	"	19,750	2.61	163.0	1–152	
	Rockport, Mass.	Bed	16,300	"	"	"	

KIND.	LOCALITY.	Position.	Crushing strength per inch.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Remarks.
	Westerly, R. I.	Bed	17,500	2.65	165.6	None	
	Millstone Point, Conn.		17,450	2.71	168.7	"	
	Niantic River, Conn.	Edge	14,175	2.66	166.2		
	Mystic River, Conn.	Bed	20,000	2.63	164.0		
	Staten Isl., N. Y.	"	22,250	2.86	178.8	None	
	Morrisania, N. Y.		15,800	2.72			
	Pompton, N. J.		24,000				
	Port Deposit, Md.	Bed	17,100	2.72	170.0		
	Port Deposit, Md.	Edge	13,100	"	"		
	Richmond, Va.	Bed	14,000	2.63	164.0	1–348	
	Huron Isl., Mich.	"	19,400	2.66	166.2	1–630	
	Huron Isl., Mich.	Edge	14,425	2.62	164.0		
	Duluth, Minn.	Bed	17,500	2.80	175.0	1–711	
	St. Cloud, Minn.	"	17,250	2.69	168.0	1–239	
	Average 39 other specimens.		17,253	2.67	166.0		Highest 22,750
	Average 20 other specimens.		11,700	"	172.0		Lowest 7,750

CRUSHING STRENGTH OF STONES AND BRICKS.

DESCRIPTION OF MATERIAL.	Specific gravity.	Tons per square inch.
Granite:—Aberdeen, blue	2.625	4.87
Peterhead	....	3.70
Cornish	2.662	2.83
Dublin	....	4.66
Wicklow	....	1.52

Crushing Strength of Stones and Bricks.

DESCRIPTION OF MATERIAL.	Specific gravity.	Tons per square inch.
Granite:—Newry	....	5.86
Mount Sorrel.	2.675	5.74
Whinstone, Scotch	....	3.70
Greenstone, Irish	....	9.30
Sandstones and Grits:—		
Arbroath pavement	....	3.52
Craigleith freestone	2.452	2.61
Derby grit, friable sandstone	2.316	1.40
Yorkshire paving	2.507	2.55
Red sandstone, Runcorn	....	0.97
Quartz rock, Holyhead, across lamination	....	11.40
" parallel to lamination.	....	6.25
Marble:—Statuary	....	1.44
Italian, white, veined	....	4.32
Limestones:—Compact	2.584	3.44
Purbeck	2.599	4.09
Magnesian	....	1.36
Anglesea	2.720	3.38
Irish	....	5.06 to 7.56
Chalk	....	0.224
Slates:—Irish, on bed of strata	....	10.60
" on edge of strata	....	6.23
Bricks:—Red	....	0 358
Yellow-faced, baked	....	0.446
" burnt	....	0.643
Gault-clay, pressed	....	1.111
" wire-cut	....	0.884
" perforated	....	1.180
Stock	....	1.044
Fareham, red	....	2.500
Staffordshire, blue, pressed with frogs.	....	3.100
Staffordshire, blue, rough without frogs	....	3.275
Stourbridge fire-clay	....	0.766
" "	....	0.670
Tividale blue	....	0.620
Brick-work in cement not hard.	....	0.232
Portland cement, 3 months old	....	1.70
1 do. to 1 sand " "	....	1.11
1 do. to 5 sand " "	....	0.43
Portland cement, 9 months old	....	2.67
1 do. to 1 sand " "	....	2.04
1 do. to 5 sand " "	....	0.75
Portland cement, concrete blocks—12 inch cubes compressed, 12 months old.		Total crushing weight, tons.
1 cement to 1 sand and gravel	....	170.5

Crushing Strength of Stones and Bricks.

DESCRIPTION OF MATERIAL.	Specific gravity.	Total crushing weight, tons.
1 cement to 3 sand and gravel............	....	115.5
1 " to 6 " "	....	91.0
		Per square inch.
Mortar:—Lime and river sand................	....	0.194
" " beaten.....	....	0.266
Lime and pit sand................	....	0.258
" " beaten.......	....	0.357
Glass	....	12.31 to 14.23

MISCELLANEOUS RULES FOR COMPUTING MEASUREMENTS, POWER, ETC.

Some Comparative Linear Measurements.

NAME.	English Feet.	English Miles.
English mile	5280	1.0
U. S. statute mile..............................	5280	1.0
Roman mile.....................................	4854	.9193
Scotch mile (old)...............................	5950.5	1.127
Irish mile (old)	6721.5	1.273
German mile (short)............................	20576	3.897
German mile (long).............................	30376	5.753
Prussian mile....................................	24710.5	4.680
Danish mile......................................	24731.5	4.684
Swedish mile....................................	35101.5	6.648
English nautical mile.........................	6087.84	1.153
German nautical mile.........................	24346.08	4.611
English land league...........................	15840	3.0
French legal post league.....................	12777.6	2.42
Spanish league...................................	21444	4.061
Nautical league (1-20 of a degree or 3 nautical miles)................................	18263.52	3.457875

The terms geographical and nautical are identical when used in reference to miles and leagues.

Convenient Multipliers.—For the circumference of a circle, multiply diameter by 3.146.

For the diameter of a circle, multiply circumference by 0.31831.
For the area of a circle, multiply square of diameter by 0.7854.
For the side of an equal square, multiply diameter by 0.8862.
For the surface of a ball, multiply square of diameter by 3.1416.
For the cubic inches in a ball, multiply cube of diameter by 0.5236.

Rule to Compute Power Necessary to Raise a Given Weight with a Lever.—Multiply weight to be raised by its distance from fulcrum and divide product by distance of power from

fulcrum. *Example:* Weight to be raised 1000 lbs., length of lever 7 feet, distance of weight from fulcrum 2 feet—hence:

$$\frac{1000 \times 2}{7 - 2} = \frac{2000}{5} = 400$$

Working Load for Wire Rope.—The proper safe working load for wire rope is as follows: One-half inch in diameter, 1000 lbs.; five-eighths inch, 1500 lbs.; three fourths inch, 3500 lbs.; one inch, 6000 lbs. This is for 19 wires to the strand, hemp centres.

To find out how much Wire it takes to Wrap round a Cylinder in a Spiral.—Multiply the circumference of the base by the number of revolutions of the spiral, and to the square of the product add the square of the height; the square root of the same will be the length of the spiral. The diameter of the cylinder must be considered as extending to the middle of the thickness of the wire.

To get the Contents of a Turnip-shaped Body.—Multiply the length of the short axis by the square of the long one and the product by 0.5236.

To find the Weight of a Cast-iron Ball.—Multiply the cube of the diameter in inches by 1365 and the product is the weight in pounds.

To Measure Belting in the Roll.—A simple method of measuring belting in the roll, and which is said to be very closely correct, is as follows: The sum of the diameter of the outside and inside of the roll in inches, multiplied by the number of turns made by the belt, and this product multiplied by the decimal .1309, will be the length of the belt in feet.

Simple Mode of Calculating the Height of an Object.—One of the simplest means of doing this, and that will give results very near the truth—sufficiently so for all practical purposes if carefully done—is to compare the length of the shadow cast by the object with that of an object whose height is known. Thus, suppose, the object whose height is desired to be known is a tree. The only apparatus required will be a tape measure, or other means of making a measurement, and a stick. Force the end of a stick (say 2 or 3 feet long) into the earth so that it will stand vertically. Measure carefully the length of the stick that projects above the ground; then measure the length of its shadow. This will give the necessary ratio for the height of the tree. Measure with the same care the length of the shadow cast by the tree; multiply this by the ratio found, and the quotient will give the desired result with a degree of accuracy depending, of course, on the care with which the measurements were made. As an example let us make the following supposition: Let the stick in question have 3 feet projecting above the ground, let its shadow measure $4\frac{1}{2}$ feet. The ratio between the height of the stick and the length of the shadow is, therefore, 3 divided by $4\frac{1}{2} = \frac{2}{3}$, which is the factor by which the length of the shadow cast by the tree must be multiplied to give the height of the tree.

To Compute the Weight of Pipes per foot.—Subtract the square of the internal diameter from the square of the external diameter, both in inches, and multiply—

For cast iron pipe.................................... by 2.45
For wrought iron pipe................................ by 2.64
For brass tubes .... by 2.82
For copper tubes...................................... by 3.03
For lead pipe.. by 3.86

TABLE OF WEIGHTS PER FOOT OF WROUGHT-IRON PIPE.

Inside Diameter.	Weight Per Foot.	Inside Diameter.	Weight Per Foot.
⅛ inch	.24 pounds	3 inches	7.54 pounds
¼ inch	.42 pounds	3½ inches	9.05 pounds
⅜ inch	.56 pounds	4 inches	10.72 pounds
½ inch	.85 pounds	4½ inches	12.49 pounds
¾ inch	1.12 pounds	5 inches	14.56 pounds
1 inch	1.67 pounds	6 inches	18.77 pounds
1¼ inches	2.25 pounds	7 inches	23.41 pounds
1½ inches	2.69 pounds	8 inches	28.25 pounds
2 inches	3.66 pounds	9 inches	34.07 pounds
2½ inches	5.77 pounds	10 inches	40.64 pounds

Comparison of the Scales of Fahrenheit's, the Centigrade, and Réaumur's Thermometers.—These three thermometers are graduated so that the range of temperature, between the freezing and boiling points of water, is divided by Fahrenheit's scale into 180 (from 32° to 212°), by the Centigrade into 100 (from 0° to 100°) and by that of Réaumur into 80 (from 0° to 80°) portions or degrees.

The spaces occupied by a degree of each scale are consequently as $\frac{1}{9}$, $\frac{1}{5}$ and $\frac{1}{4}$ respectively, or as 1, 1.8, and 2.25; and the number of degrees denoting the same temperature, by the three scales, when reduced to a common point of departure by subtracting 32 from Fahrenheit, are as 9, 5 and 4. Hence we derive the following equivalents.

A degree of Fahrenheit is equal to 0.5 of the Centigrade, or to 0.4 of Réaumur's; a degree of the Centigrade is equal to 1.8 of Fahrenheit's or to 0.8 of Réaumur's; and a degree of Réaumur's is equal to 2.25 of Fahrenheit's or to 1.25 of the Centigrade.

To convert degrees of Fahrenheit into the Centigrade or Réaumur's, subtract 32 and multiply the remainder by $\frac{5}{9}$ for the Centigrade, or $\frac{4}{9}$ for Réaumur's. To convert degrees of the Centigrade or Réaumur's into Fahrenheit's multiply the Centigrade by $\frac{9}{5}$, or Réaumur's by $\frac{9}{4}$, as the case may be and add 32 to the product.

Definition of the "Legal Ohm," and of the Siemens Unit of Resistance.—The Paris Congress defined the "legal ohm" as "the resistance of a column of mercury 106 centimetres (4.13 inches) long and 1 square millimetre (0.001 square inch) in section, at the temperature of melting ice." Many physicists consider 106.2 centimetres (4.141 inches) or 106.25 centimetres (4.143 inches) as nearer the correct value than that adopted by the Paris Congress.

The Sièmens unit is the resistance of a column of mercury 1 metre (3 feet 3.37 inches) long and 1 square metre (10.76 square feet) in section at 0° C. (32° F.).

Wind Pressure.—An estimate, by careful measurements made in a level country, representing less than the average, gives the following results:

Velocity in Miles per Hour.	Pressure in Pounds per Square Foot.		
	Round.	Square.	Triangular.
1	0.003	0.003	0.004
2	0.014	0.014	0.013
3	0.030	0.031	0.032
4	0.054	0.055	0.057
5	0.085	0.086	0.088
10	0.339	0.345	0.353
15	0.763	0.777	0.795
20	1.356	1.382	1.413
25	2.119	2.159	2.208
30	3.052	3.109	3.180
35	4.154	4.232	4.328
40	5.425	5.527	5.653
45	6.866	6.996	7.155
50	8.476	8.637	8.833
60	12.208	12.437	12.719
80	21.701	22.110	22.613
100	33.908	34.546	35.332

To Estimate Brick-work.—Ordinary bricks are about 8 inches in length and with the mortar joint about half that in width, so that each brick on the flat will give a horizontal surface of about 32 square inches, or 4½ bricks will cover a square foot. As ordinarily laid there are nine courses to every 24 inches, or 4½ to the foot. Four and a half courses, with 4½ bricks to the course, will give 20¼ bricks to the cubic foot. Waste, cutting and closer joints will easily require an allowance of 21 bricks per cubic foot, which will be found a very convenient figure in estimating the number of bricks required for a wall of given height and thickness, as it thus becomes not necessary to find the cubic contents of the wall, but merely to multiply its face area, or the product of its length and height in feet, by seven-fourths of its thickness in inches, which, as the thickness is always some multiple of four inches, is a very simple process.

Plastering.—*Amount of materials required for* 100 *square yards average "two coat" or "coat and skim work."*

Sand, ordinary work		40 cubic ft.
Lime, " " with common sand		6 bushels.
Hair, " " " " "		1½ "
Lath, 1½ in. wide, nailed ⅜ in. apart		1440
Nails, 3d fine	studding or joist 16 in. apart	10 lbs.
Nails, 3d fine	studding or joist 12 in. apart	12 lbs.

Three Coat Work (good, to grounds).

Sand, on lath work	45 cubic ft.
" " brick "	55 " "
Lime, ordinary sand	8 bushels.
" clean, sharp, coarse sand	10 "
Hair, best long "Winter" hair	1 to 1¼ "
Lath, 1½ in. wide, nailed ⅜ in. apart	1440
Nails, 3d m. studding or joists 16 in. apart	10 lbs.
" " " " " " 12 " "	12 "

Capacity of Cylindrical Cisterns.—The following table shows the capacity in gallons for each foot in depth of cylindrical cisterns of any diameter:

Diameter.	Gallons.	Diameter.	Gallons.
25 feet	3,059	7 feet	239
20 "	1,095	6½ "	206
15 "	1,101	6 "	176
14 "	959	5 "	122
13 "	827	4½ "	99
12 "	705	4 "	78
11 "	592	3 "	44
10 "	489	2½ "	30
9 "	396	2 "	19
8 "	313		

Rule for Measuring Cylindrical Cisterns and Wells.—The square of diameter in inches, multiplied by depth in inches, and the product multiplied by 0.0034, equals contents in gallons.

TABLE OF SOLUBILITY OF A FEW ANILINE COLORS.

For the preparation of alcoholic or aqueous solutions of aniline colors the following table may prove useful:

Name.	Soluble in water. Per cent.	Soluble in alcohol Per cent.
Aurin	Almost insoluble.	40
Bismarck brown	3	0.35
Coralline	2	0.5
Dahlia blue	4	1
Eosine	2	1
Ethyl orange	0.02	Nearly insoluble.
Fuchsine	0.3	10
Gentian violet	1.5	3
Luteoline	0.25	0.6
Magenta red	0.2	2.5
Malachite green	4	5
Manchester yellow	2	0.15
Methyl blue	3	1.5
Methyl green	7	0.25
Methyl violet	2	1.5
Safranine	0.6	0.4
Tropeoline	0.05	0.1
Vesuvine	2	0.2

Gas-holders.—*The pressure due to the weight of a gas-holder* may be found by the following rule: Multiplying the area of the gas-holder in square feet by 5.21, and with the product divide the weight

of the gas-holder in lbs., the quotient will be the pressure in inches deep of water.

The weight of the counterbalance weight to make a gas-holder work at a given inches of water may be found thus: *Rule.*—Multiply the area of the gas-holder in square feet by 5.21, and by pressure of water in inches, and subtract the product from the weight in lbs. of the gas-holder.

The diameter of a gas-holder to hold the maximum quantity of cubic feet of gas required for 24 hours may be found thus: *Rule.*—Divide the quantity in cubic feet of gas by the product of the depth of the gas-holder by 0.7854, and the square root of the product will be the diameter of the gas-holder.

BOILER INCRUSTATION.

Great drawbacks arise from the incrustation of boilers, and hence the importance of any mode by which it can be prevented. The most obvious way is, of course, to use good water; but when one kind of water only is available (such as is the case of towns and cities) and that kind bad, the next plan open to the users of steam-power is to employ a mode of preventing the scale or deposit; and here the difficulty comes in play how to choose amongst so many plans.

The acids which cause "pitting," "channeling," "furrowing," "grooving," etc., held in solution in the water fed to the boiler and set free by heat, are beyond the reach of any mechanical devices, and can only be neutralized by a chemical combination, which is known to the trade as boiler solvents.

Lord's Compound. The boiler compound of George W. Lord, of Philadelphia, Pa., has a high reputation as a scale preventer, and has been used successfully for many years by many representative establishments throughout the United States and Canada. It is highly recommended for neutralizing the acids in feed waters, and also for the prevention and removal of scaly deposits without in any manner injuring the material of the boiler, as testified to over their signatures by Messrs. Booth & Garrett, chemists, of Philadelphia, who stand at the head of their profession.

This compound is manufactured dry, in the form of a granulated powder, in appearance resembling common brown sugar, and is put up in packages of convenient size—half-barrels, barrels and casks—covering a wide range in weight of from 25 to 500 lbs., for the convenience of small and large consumers. It readily dissolves in water, and can therefore be applied in a dry state through the man-hole, or in a liquid state by the feed-pump, whichever is most convenient.

The quantity for an application will depend upon the nature and amount of water evaporated, the composition of the scale, the construction of the boiler, etc., but for general use a half-pound per horse-power per month has been found to give satisfactory results.

When judiciously applied, this compound will never fail to meet the most sanguine expectations of the purchaser, but being composed of chemicals which are harmless to boiler material, its action may require a longer period than would be needed by many of the dangerous and worthless compounds made of refuse acids, which, while removing the scale, likewise destroy the boiler iron by their corrosive action.

Lord's compound is probably the only one of its kind that is unanimously endorsed by professional men throughout the length and

breadth of this continent. This unanimous endorsement is probably due to the fact that not a single accident has occurred to any boiler in which this compound is used, although such boilers are to be found in every steam-using locality from Canada to Mexico and from Maine to the Pacific slope. No stronger recommendation of its merits can be given.

The following remedies have also been recommended to prevent incrustation:

1. Potatoes, $\frac{1}{50}$th weight of the water; said to prevent adherence of scale.
2. Salt 12 parts, caustic soda $2\frac{1}{2}$, extract of oak bark $\frac{1}{8}$, potash $\frac{1}{2}$.
3. Pieces of oak-wood suspended in boiler and renewed monthly.
4. Muriate of ammonia about 2 ozs., introduced into the boiler twice a week.
5. A coating of 3 parts of black lead, 18 of tallow, applied hot to the inside of the boiler every few weeks.
6. Molasses fed into the boiler at intervals.
7. Mahogany or oak sawdust in small quantities. Use this with caution, as the tannic acid attacks iron.
8. Carbonate of soda.
9. Slippery elm bark.
10. Chloride of tin.
11. Spent tanner's bark.
12. Pulverized soapstone. P. Vigier recommends this as an excellent means to prevent the deposition of incrustations, especially when carbonates are present. The pulverized soapstone acquires a lively motion in boiling fluids and thus prevents mechanically the deposition of calcium carbonate in dense masses. By a series of experiments Vigier has determined that it suffices to add to the respective water the tenth part of its residue of evaporation of pulverized soapstone to effectively prevent the formation of incrustation. Suppose a boiler requires for daily feeding 220 gallons of water which leave a solid residue of 7 ozs., 0.7 oz. of pulverized soapstone would have to be daily introduced into the boiler. The separated pulverulent carbonates together with the addition of soapstone will have to be removed by a periodical discharge of the entire contents of the boiler.

Part II.

RARE AND VALUABLE RECEIPTS AND TABLES FOR MECHANICAL PURPOSES.

Yellow Brass, for Turning.—(Common article.)—Copper, 20 lbs.; zinc, 10 lbs.; lead from 1 to 5 oz. Put in the lead last before pouring off.

Red Brass, for Turning.—Copper, 24 lbs.; zinc, 5 lbs., lead, 8 oz. Put in the lead last before pouring off.

Red Brass, free, for Turning.—Copper, 160 lbs.; zinc, 50 lbs.; lead, 10 lbs.; antimony, 44 oz.

Another Brass, for Turning.—Copper, 32 lbs.; zinc, 10 lbs; lead, 1 lb.

Best Red Brass, for Fine Castings.—Copper, 24 lbs.; zinc, 5 lbs ; bismuth, 1 oz. Put in the bismuth last before pouring off.

Bronze Metal.—Copper, 7 lbs.; zinc, 3 lbs.; tin, 2 lbs.

Bronze Metal.—Copper, 1 lb.; zinc, 12 lbs.; tin, 8 lbs.

Bell Metal, for Large Bells.—Copper, 100 lbs.; tin, from 20 to 25 lbs.

Bell Metal, for Small Bells.—Copper, 3 lbs.; tin, 1 lb.

Cock Metal.—Copper, 20 lbs.; lead, 8 lbs.; litharge, 1 oz.; antimony, 3 oz.

Hardening for Britannia.—(To be mixed separately from the other ingredients.)—Copper, 2 lbs.; tin, 1 lb.

Good Britannia Metal.—Tin, 150 lbs.; copper, 3 lbs.; antimony, 10 lbs.

Britannia Metal, second Quality.—Tin, 140 lbs.; copper, 3 lbs.; antimony, 9 lbs.

Britannia Metal, for Casting.—Tin, 210 lbs.; copper, 4 lbs.; antimony, 12 lbs.

Britannia Metal, for Spinning.—Tin, 100 lbs.; Britannia hardening, 4 lbs.; antimony, 4 lbs.

White Solder, for Raised Britannia Ware.—Tin, 100 lbs.; copper, 3 oz., to make it free; and lead, 3 oz.

Britannia Metal, for Registers.—Tin, 100 lbs.; hardening, 8 lbs.; antimony, 8 lbs.

Best Britannia, for Spouts.—Tin, 140 lbs.; copper 3 lbs.; antimony, 6 lbs.

Best Britannia, for Spoons.—Tin, 100 lbs.; hardening, 5 lbs.; antimony, 10 lbs.

Best Britannia, for Handles.—Tin, 140 lbs.; copper, 2 lbs.; antimony 5 lbs.

Best Britannia, for Lamps, Pillars and Spouts.—Tin, 300 lbs.; copper, 4 lbs.; antimony, 15 lbs.

Casting.—Tin, 100 lbs.; hardening, 5 lbs.; antimony, 5 lbs.

Lining Metal, for Boxes of Railroad Cars.—Mix tin, 24 lbs.; copper, 4 lbs.; antimony, 8 lbs. (for a hardening); then add tin, 72 lbs.

Fine Silver Colored Metal.—Tin, 100 lbs.; antimony, 8 lbs.; copper, 4 lbs.; bismuth, 1 lb.

German Silver, First Quality, for Casting.—Copper, 50 lbs.; zinc, 25 lbs.; nickel, 25 lbs.

German Silver, Second Quality, for Casting.—Copper, 50 lbs.; zinc, 20 lbs.; nickel (best pulverized), 10 lbs.

German Silver, for Rolling.—Copper, 60 lbs.; zinc, 20 lbs.; nickel, 25 lbs.

German Silver, for Bells and other Castings.—Copper, 60 lbs.; zinc, 20 lbs.; nickel, 20 lbs.; lead, 3 lbs.; iron (that of tin plate being best,) 2 lbs.

Imitation of Silver.—Tin, 3 oz.; copper, 4 lbs.

Pinchbeck.—Copper, 5 lbs.; zinc, 1 lb.

Tombac.—Copper, 16 lbs.; tin, 1 lb.; zinc, 1 lb.

Red Tombac.—Copper, 10 lbs.; zinc, 1 lb.

Hard White Metal.—Sheet brass, 32 oz.; lead, 2 oz.; tin, 2 oz.; zinc, 1 oz.

Metal for taking Impressions.—Lead, 3 lbs.; tin, 2 lbs.; bismuth, 5 lbs.

Spanish Tutania.—Iron or steel, 8 oz.; antimony, 16 oz.; nitre, 3 oz. Melt and harden 8 oz. tin with 1 oz. of the above compound.

Rivet Metal.—Copper, 32 oz.; tin, 2 oz.; zinc, 1 oz.

Rivet Metal, for Hose.—Tin, 64 lbs.; copper, 1 lb.

Fusible Alloy.—(Which melts in boiling water).—Bismuth, 8 oz.; tin, 3 oz.; lead, 5 oz.

Fusible Alloy, for Silvering Glass.—Tin, 6 oz., lead, 10 oz.; bismuth, 21 oz.; mercury, a small quantity.

Best Soft Solder for Cast Britannia Ware.—Tin, 8 lbs.; lead, 5 lbs.

Yellow Solder, for Brass or Copper.—Copper, 32 lbs.; zinc, 29 lbs.; tin, 1 lb.

Brass Solder.—1. Copper, 61.25 parts; zinc, 38.75 parts; 2. (Yellow and easily fusible) copper, 45 parts; zinc, 55 parts; 3. (White) copper, 57.41 parts, tin, 14.60 parts; zinc, 27.99 parts.

Solder, for Copper,—Copper, 10 lbs.; zinc, 9 lbs.

Black Solder.—Copper, 2 lbs.; zinc, 3 lbs.; tin, 2 oz.

Black Solder.—Sheet brass, 20 lbs.; tin, 6 lbs.; zinc, 1 lb.

Soft Solder.—Tin, 15 lbs.; lead, 15 lbs.

Pewterer's Soft Solders.—1. Bismuth, 2; lead, 4; tin, 3. 2. Bismuth, 1; lead, 1; tin, 2.

Plumber's Solder.—Lead, 3 parts; tin, 1 part.

Solder.—For lead, the solder is one part tin, 1 to 2 of lead; for tin, 1 to 2 parts tin to 1 of lead; for zinc, 1 part tin to 1 to 2 of lead; for pewter, 1 part tin to 1 of lead, and 1 to 2 parts of bismuth.

The surfaces to be joined are made perfectly clean and smooth, and then covered with sal ammoniac, or resin, or both; the solder is then applied, being melted in, and smoothed over by the soldering iron.

Coppersmith's Cement, &c.—Bullock's blood thickened with finely-powdered lime. Use as soon as mixed, as it rapidly gets hard. Coppersmith's solder.—Tin 2 parts, lead 1 part. When the copper is thick, heat it by a naked fire; if thin, use a tinned copper tool. Use muriate or chloride of zinc, or resin, as a flux. The same solder will do for iron, cast iron, or steel; if thick, heat by a naked fire, or immerse in the solder.

Solder for Gold.—Gold, 6 dwts.; silver, 1 dwt.; copper, 2 dwts.

Soft Gold Solder.—Gold, 4 parts; silver, 1 part; copper, 1 part.

Solder for Silver.—(For the use of jewellers.)—Fine silver, 19 dwts.; copper, 1 dwt., sheet brass, 10 dwts.

White Solder, for Silver.—Silver, 1 oz.; tin, 1 oz.

Silver Solder, for Plated Metal.—Fine silver, 1 oz.; brass, 10 dwts.

Solders.—For Steel Joints. Silver, 19 parts; copper, 1 part; brass, 2 parts; melt altogether.

Hard Solder.—Copper, 2 parts; zinc, 1 part; melt together.

For Gold.—1. Silver, 7 parts; copper, 1 part, with borax. 2. Gold, 2 parts; silver, 1 part; copper, 1 part. 3. Gold, 3 parts; silver, 3 parts; copper, 1 part; zinc, ½ part.

For Silver.—Silver, 2 parts; brass, 1 part, with borax; or, silver, 4 parts; brass, 3 parts; zinc, 1-16, with borax.

For Brass.—Copper, 3 parts; zinc, 1 part, with borax.

For Platina.—Gold, with borax.

For Iron.—The best solder for iron is good tough brass, with a little borax.

For Copper.—Brass, 6 parts; zinc, 1 part; tin, 1 part; melt all together, mix well, and pour out to cool.

Gold Solders.—1. Copper, 24.24 parts; silver, 27.57 parts; gold, 48.19 parts. 2. Enamel solder—Copper, 25 parts; silver, 7.07 parts; gold, 67.93 parts. 3. Copper, 26.25 parts; zinc, 6.25 parts; silver, 31.25 parts; gold, 36.25 parts. 4. Enamel solder—Silver, 19.57 parts; gold, 80.43 parts.

Solders.—For 22 carat gold—Gold of 22 carats, 1 dwt.; silver, 2 gr.; copper, 1 gr.

For 18 carat gold—Gold of 18 carats, 1 dwt.; silver, 2 gr.; copper, 1 gr.

For cheaper gold—Gold, 1 dwt.; silver, 10 gr.; copper, 8 gr.

Cheaper still—Fine gold, 1 dwt.; silver, 1 dwt.; copper, 1 dwt.

Silver Solders.—1. (*hard.*) Copper, 30 parts; zinc, 12.85 parts; silver, 57.15 parts. 2. Copper, 23.33 parts; zinc, 10.00 parts; silver, 66.67 parts. 3, Copper, 26.66 parts; zinc, 10.00 parts; silver, 63.34 parts. 4. (*soft.*) Copper, 14.75 parts; zinc, 8.20 parts; silver, 77.05 parts. 5. Copper, 22.34 parts; zinc, 10.48 parts; silver, 67.18 parts. 6. Tin, 63.00 parts; lead, 37 parts.

Colored Gold.—1. Full red gold.—Gold, 5 dwt.; copper, 5 dwt. 2. Red gold.—Gold, 10 dwt.; silver, 1 dwt.; copper, 4 dwt. 3. Green gold.—Gold, 5 dwt.; silver, 21 gr. 4. Gray gold.—Gold, 3 dwt. 15 gr.; silver, 1 dwt. 9 gr. 5. Blue gold.—Gold, 5 dwt.; steel filings, 5 dwt. 6. Antique gold, greenish-yellow.—Gold, 18 dwt. 9 gr.; silver, 21 gr.; copper, 18 gr. These all require to be submitted to the process of wet-coloring. 7. Factitious gold, very bright.—Copper, 16 parts; platina, 7 parts; zinc, 1 part; fused together.

Alloys for Gold.—1. Red gold.—Copper, 66.67 parts; gold 33.33 parts. 2. Yellow gold.—Copper, 12.50 parts; silver, 37.50 parts; gold, 50 parts. 3 Green gold.—Silver, 25 parts; gold, 75 parts. 4. Yellow gold.—Silver, 66.67 parts; gold, 33.33, parts; 5. Gray gold.—Silver, 5.89 parts; gold, 88.23 parts; iron, 5.89 parts. 6. Dentists' gold.—Silver, 8.34 parts; platinum, 66.67 parts; gold, 24.29 parts. 7. English gold coin.—Copper, 8.34 parts; gold, 91.66 parts. 8. American gold coin.—Copper, 10 parts; gold, 90 parts. French gold coin same as American.

Alloys for Silver Coin and Plate.—1. English standard.—Copper, 7.50 parts; silver, 92.50 parts. 2. American standard.—Copper, 10 parts; silver, 90 parts. French the same.

Gilding Metal for common jewelry is made by mixing 4 parts copper with one of calamine brass. Sometimes 1 lb. copper with 6 oz. of brass.

Jeweller's Gold Compositions, Common Gold.—Silver, 1 part; Spanish copper, 16 parts; gold, 2 parts; mix. Ring gold.—Spanish copper, 6 parts; silver, 3 parts; gold, 5 parts; mix. Manheim gold —Copper, 3 parts; zinc, 1 part; melt, and stir well. Mosaic gold.—Copper and zinc, equal parts; melt at the lowest temperature that will fuse the former, then mix by stirring, and add 5 per cent. more zinc. Parker's mosaic gold.—Copper, 100 parts; zinc 54 parts; mix. For common jewelry.—Copper, 3 parts; 1 of old brass, and 4 oz. of tin to every pound of copper.

Factitious Gold.—Copper, 16 parts; platinum, 7 parts; zinc, 1 part; fused together. This alloy resembles gold of 16 carats fine, or ⅔, and will resist the action of nitric acid, unless very concentrated and boiling.

Harmstadt's True Imitation of Gold is stated not only to resemble gold in color, but also in specific gravity and ductility. Platinum, 16 parts; copper, 7 parts; zinc, 1 part; put in a crucible, cover with charcoal powder, and melt into a mass.

Do. of Silver.—Copper, ¼ oz.; brass, 2 oz.; pure silver, 3 oz.; bismuth, 2 oz.; saltpetre, 2 oz.; common salt, 1 oz.; arsenic, 1 oz.; potash, 1 oz.; melt in a crucible with powdered charcoal. This compound was used by a German chemist for unlawful purposes to the amount of thousands, and is so perfect that he was never discovered.

Artificial Gold.—This is a new metallic alloy which is now very extensively used in France as a substitute for gold. Pure copper, 100 parts; zinc, or, preferably, tin, 17 parts; magnesia, 6 parts; sal-ammoniac, 3-6 parts; quick-lime, ⅛ part; tartar of commerce, 9 parts; are mixed as follows: The copper is first melted, and the magnesia, sal-ammoniac, lime, and tartar are then added, separately, and by degrees, in the form of powder. The whole is now briskly stirred for about half an hour, so as to mix thoroughly; and then the zinc is added in small grains by throwing it on the surface, and stirring till it is entirely fused; the crucible is then covered, and the fusion maintained for about thirty-five minutes. The surface is then skimmed, and the alloy is ready for casting.

It has a fine grain, is malleable, and takes a splendid polish. It does not corrode readily, and, for many purposes, is an excellent substitute for gold. When tarnished, its brilliancy can be restored by a little acidulated water. If tin be employed instead of zinc, the alloy will be more brilliant. It is very much used in France, and must ultimately attain equal popularity here.

New French Patent Alloy for Silver.—Messieurs DeRuolz & Fontenay have invented the following alloy, which may be used for almost all purposes for which silver is usually employed: Silver, 20 parts; purified nickel, 28 parts; copper, 52 parts. Melt the copper and nickel in the granular state, then introduce the silver. The flux to be employed is charcoal and borax, both in the state of powder; and the ingots obtained are to be rendered malleable by annealing for a considerable time in powdered charcoal.

Alloys for Gold.—22 parts gold, 2 parts copper, is 22 carats fine; 20 parts gold, and 4 parts copper, is 20 carats fine; 18 parts gold, and 6 parts copper, is 18 carats fine.

English Standard for Silver.—Pure silver, 11 oz. 2 dwts.; copper, 22 dwts. Melt.

Silver Imitations.—Copper 1 lb.; tin, ¾ oz.; melt. This composition will roll and ring very near to silver. BRITANNIA METAL.—Copper, 1 lb.; tin, 1 lb.; regulus of antimony, 2 lbs.; melt together, with or without a little bismuth. GENUINE GERMAN SILVER.—Iron, 2½ parts; nickel, 31½ parts; zinc, 25½ parts; copper, 40½ parts; melt. FINE WHITE GERMAN SILVER.—Iron, 1 part; nickel, 10 parts; zinc, 10 parts; copper, 20 parts; melt. PINCH-

BECK.—Copper, 5 parts; zinc, 1 part; melt the copper, then add the zinc. JEWELLER'S METAL.—Copper, 30 parts; tin, 7 parts; brass, 10 parts. Mix.

French Gold Plate.—1. Gold, 92 parts; copper, 8 parts. 2. Gold, 84 parts; copper, 16 parts. 3. Gold, 75 parts; copper, 25 parts.

Bidery.—Copper, 48.48 parts; tin, 6.60 parts; zinc, 33.80 parts; lead, 12.12 parts.

Best Brass for Clocks.—Rose copper, 85 parts; zinc, 14 parts; lead, 1 part.

Alloy for Watch Pinion Sockets.—Gold, 31 parts; silver, 19 parts; copper, 39 parts; palladium, 1 part.

To Reduce Hair-Springs.—Immerse the springs about 2 or 3 seconds in nitric acid, 3 drops to one teaspoonful of water. By this means you can reduce them to any extent. It requires very careful manipulation, experience, and good judgment.

Albata Metal.—Nickel, 3 to 4 parts; copper, 20 parts; zinc, 16 parts. Used for plated goods.

British Plate.—Nickel, 5 to 6 parts; copper, 20 parts; zinc, 8 to 10 parts. Used for plated goods.

Chantry's Hard Alloy.—Copper, 1 lb.; zinc, 2½ oz.; tin, 2½ oz. Razors as hard as tempered steel have been made from this alloy.

Hard White Metal for Buttons.—Brass, 1 lb.; zinc, 2 oz.; tin, 1 oz.

Birmingham Platin.—Copper, 8 parts; zinc, 5 parts.

German Silver.—1. Copper, 40.62 parts; zinc, 43.76 parts; nickel, 15.62 parts. 2. Copper, 41.47 parts; zinc, 26.08 parts; nickel, 32.45 parts. 3. Copper, 55.55 parts; zinc, 5.55 parts; nickel, 38.90 parts. 4. Copper, 53.40 parts; zinc, 29.10 parts; nickel, 17.50 parts. 5. (*Alfenide* contains a trace of iron.) Copper, 59.60 parts; zinc, 30.30 parts; nickel, 10.10 parts.

Britannia Metal.—1. Copper, 0.30 parts; tin, 89.70 parts; zinc, 0.30 parts; antimony, 9.70 parts. 2. Copper, 1.85 parts; tin, 81.64 parts; antimony, 16.51 parts. 3. Copper, 0.91 parts; tin, 89.97 parts; antimony, 9.12 parts. 4. Tin, 90.00 parts; antimony, 10 parts. 5. Copper, 1.78 parts; tin; 89.30 parts; antimony, 7.14 parts; bismuth, 1.78 parts.

Gun Metal.—Copper, 90 parts; tin, 10 parts.

Melting Point of Metals.—Iron fuses at 2787° Fahr.; gold at 2016°; silver, 1873°; copper, 1996°; zinc, 773°; antimony, 809°; bismuth, 476° to 507°; nickel, 630°; tin, 442°; lead, 334°; mercury volatilizes at 670°.

Chinese Gong Metal.—Copper, 78.00 parts; tin, 22.00.

Alloy for Gun Mountings.—Copper, 80 parts; tin, 3; zinc, 17.

Bell Metal.—1. Copper, 60 parts; tin, 40 parts. 2. Copper, 80 parts; tin, 20 parts. 3. (*Thomson's*) Copper, 80 parts; tin, 10.10 parts; zinc, 5.60 parts; lead, 4.30 parts.

White Metal for Table Bells.—Copper 2.06 parts, tin 97.31 parts, bismuth 0.63 parts.

Clock Bell Metal.—Copper 75.19 parts, tin 48.81 parts.

Socket Metal for Locomotive Axle-trees.—1. Copper 86.03, tin 13. 97; 2. (*French*) Copper 82 parts, tin 10 parts, zinc 8 parts; 3. (*Stephenson's*) Copper 79 parts, tin 8 parts, zinc 5 parts, lead 8 parts; 4. (*Belgian*) Copper 89.02 parts, tin 2.44 parts, zinc 7.76 parts iron, 0.78 parts; 5. (*English*) Copper, 73.96 parts, tin, 9.49 parts, zinc, 9.03 parts, lead, 7.09 parts, iron, 0.43 parts.

Brass.—1. Copper 73 parts, zinc 27 parts; 2. Copper 65 parts, zinc 35 parts; 3. Copper 70 parts; zinc 30 parts.

Alloy for Mechanical Instruments.—Copper 1 lb., tin 1 oz.

Malleable Brass.—1. Copper 70.10 parts, zinc 29.90 parts· 2. (*Superior*) Copper 60 parts, zinc 40 parts.

Button Maker's Metal.—1. Copper 43 parts, zinc 67 parts; 2. Copper 62.22 parts, tin 2.78 parts, zinc 35.00 parts.

Metal for Sliding Levers of Locomotives.—1. Copper 85.25 parts, tin 12.75 parts, zinc 2.00 parts; 2. (*Fenton's*) Copper 5.50 parts, tin 14.50 parts, zinc 80 parts.

Alloy for Cylinders of Locomotives.—Copper 88.63 parts, tin 2.38 parts, zinc 6.99 parts.

Alloy for Stuffing Boxes of Locomotives.—Copper 90.06 parts, tin 3.56 parts, zinc 6.38 parts.

Amalgam for Mirrors.—1. Tin 70 parts, mercury 30 parts; 2. (*For curved mirrors*) tin 80 parts, mercury 20 parts; 3. Tin 8.33 parts, lead 8.34 parts, bismuth 8.33 parts, mercury 75 parts; 4. (*For spherical mirrors*) Bismuth 80 parts, mercury 26 parts.

Reflector Metal.—1. (*Duppler's*) Zinc 20 parts, silver 80 parts, 2. Copper 66.22 parts, tin 33.11 parts, arsenic 0.67 parts; 3. (*Cooper's*) Copper 57.86 parts, tin 27.28 parts, zinc 3.30 parts, arsenic 1.65 parts, platinum 9.91 parts; 4. Copper 64 parts, tin 32.00 parts, arsenic 4.00 parts; 5. Copper 82.18 parts, lead 9.22 parts, antimony 8.60 parts; 6. (*Little's*) Copper 69.01 parts, tin 30.82 parts, zinc 2.44 parts, arsenic 1.83 parts.

Metal for Gilt Wares.—1. Copper 78,47 parts, tin 2.87 parts, zinc 17.23 parts, lead 1.43 parts; 2. Copper 64.43 parts, tin 0.25 parts, zinc 32.44 parts, lead 2.86 parts; 3. Copper 72.43 parts, tin 1.87 parts, zinc 22.75 parts, lead 2.96 parts; 4. Copper 70.90 parts, tin 2.00 parts, zinc 24.05 parts, lead 3.05 parts.

Spurious Silver Leaf.—Tin 90.00 parts, zinc 9.91 parts.

Shot Metal.—1. Lead 97.07 parts, arsenic 2.93 parts; 2. Lead 99.60 parts, arsenic 0.40 parts.

Bismuth Solder.—Tin, 33.33 parts; lead, 33.33 parts, bismuth, 33.34 parts.

Alloy for Calico Printing Blocks.—Tin, 50.00 parts, lead, 33.34; bismuth, 16.66 parts.

Amalgam for Electrical Machines.—1. Tin, 25 parts; zinc, 25 parts; mercury, 50 parts; 2. Tin, 11.11 parts; zinc, 22.22 parts; mercury, 66.67 parts.

Type Metal.—1. (*For smallest and most brittle types*) Lead, 3; antimony, 1; 2. (*For small, hard; brittle types*) Lead, 4; antimony, 1; 3. (*For types of medium size*) Lead, 5; antimony, 1; 4. (*For large types*) Lead, 6; antimony, 1; 5. (*For largest and softest types*) Lead, 7; antimony, 1. In addition to lead and antimony, type metal also contains 4 to 8 per cent. of tin, and sometimes 1 to 2 per cent. of copper. Stereotype plates are made of lead, 20 parts; antimony, 4 parts; tin, 1 part.

Brass for Wire.—Copper, 34 parts; calamine, 56 parts; mix.

Britannia Metal.—1. Tin, 82 parts; lead, 18 parts; brass, 5 parts; antimony 5 parts; mix. 2. Brass, 1 part; antimony, 4 parts; tin, 20 parts; mix. 3. Plate-brass, tin, bismuth, and antimony, of each equal parts. Add this mixture to melted tin until it acquires the proper color and hardness.

Bronze.—1. Copper, 83 parts; zinc, 11 parts; tin, 4 parts; lead, 2 parts; mix. 2. Copper, 14 parts; melt, and add zinc, 6 parts; tin, 4 parts; mix.

Ancient Bronze.—Copper, 100 parts; lead and tin, each 7 parts; mix.

Alloy for Bronze Ornaments.—Copper, 82 parts; zinc, 18 parts; tin, 3 parts: mix.

Beautiful Red Bronze Powder.---Sulphate of copper, 100 parts; carbonate of soda, 60 parts; apply heat until they unite into a mass; then cool, and add copper-filings, 15 parts. Well mix, and keep them at a white heat for 20 minutes; then cool, powder, wash and dry.

Bronzing Fluid for Guns.—Nitric acid, sp. gr. 1.2; nitric ether, alcohol, murate of iron, each 1 part; mix, then add sulphate of copper, 2 parts, dissolved in water, 10 parts.

Cannon Metal.—Take tin, 10 parts; copper, 90 parts; melt.

Statuary Bronze.—1. Copper, 88 parts; tin, 9 parts; zinc, 2 parts; lead, 1 part. 2. Copper, 82½ parts; tin, 5 parts; zinc, 10½ parts; lead, 2 parts. 3. Copper, 90 parts; tin, 9 parts; lead, 1 part.

Bronze for Medals.—Copper, 89 parts; tin, 8 parts; zinc, 3 parts.

Bronze for Large Cannon.—Copper, 90; tin, 7.

Bronze for Small Cannon.—Copper, 93; tin, 7.

Alloy for Symbals.—Copper, 80; tin, 20.

Mirrors of Reflecting Telescopes.—Copper, 100; tin, 50.

White Argentine.—Copper, 8; nickel, 3; zinc, 35. This beautiful composition is in imitation of silver.

Chinese Silver.—Silver, 2.5; copper, 65.24; zinc, 19.52; cobalt of iron, 0.12; nickel, 13.

Tutenag.—Copper, 8; nickel, 3; zinc, 5.

Printing Characters.—Lead, 4; antimony, 1. For stereotype plates, lead, 25; antimony, 4; tin, 1.

Fine White German Silver.—1. *For Castings.* Lead, 3 parts; nickel, 20 parts; zinc 20 parts; copper, 60 parts; mix. 2. *For Rolling.* Nickel, 5 parts; zinc, 4 parts; copper, 12 parts; mix.

Imitation Platinum.—Melt together 8 parts brass and 5 of zinc. This alloy very closely resembles platinum.

Imitation Gold.—Platina, 8 parts; silver, 4 parts; copper, 12 parts; melt all together.

Imitation Silver.—Block-tin, 100 parts; antimony, 8 parts; bismuth, 1 part; copper, 4 parts; melt all together.

Tombac, or Red Brass.—Melt together, 8 parts of copper and 1 part of zinc.

Parisian Bell Metal.—Copper, 72 parts; tin, 26½ parts; iron, 1½ parts; used for the bells of small ornamental clocks.

Bell Metal.—1. Copper, 25 parts; tin, 5 parts; mix. 2. Copper, 79 parts; tin, 26 parts; mix. 3. Copper, 78 parts; tin, 22 parts; mix.

Prince's Metal.—1. Copper, 3 parts; zinc, 1 part. 2. Brass, 8 parts; zinc, 1 part. 3. Zinc and copper, equal parts : mix.

Queen's Metal.—1. Lead, 1 part; bismuth, 1 part; antimony, 1 part; tin, 9 parts; mix. 2. Tin, 9 parts; bismuth, 1 part; lead, 2 parts; antimony, 1 part, mix by melting.

Brass.—Copper, 3 parts; melt, then add zinc 1 part.

Button-Maker's Fine Brass.—Brass, 8 parts; zinc 5 parts.

Button-Maker's Common Brass.—Button-brass, 6 parts; tin, 1 part; lead, 1 part; mix.

Fine Brass.—Copper, 2 parts; zinc, 1 part; mix.

Organ Pipes consist of lead alloyed with about half its quantity of tin to harden it. The mottled or crystalline appearance so much admired shows an abundance of tin.

Baron Wetterstedt's Patent Sheathing for ships consists of lead, with from 2 to 8 per cent. of antimony; about 3 per cent. is the usual quantity. The alloy is rolled into sheets.

Lead Pipes are cast as hollow cylinders, and drawn out upon triblets; they are also cast of any length without drawing.

Lead Shot are cast by letting the metal run through a narrow slit into a species of colander at the top of a lofty tower; the metal escapes in drops, which, for the most part, assume the spherical form before they reach the tank of water into which they fall at the foot of the tower, and this prevents their being bruised. They are afterwards riddled or sifted for size, and afterwards churned in a barrel with black lead.

Metal for Anatomical Injections.—Tin, 16.41 parts; lead, 9.27 parts; bismuth, 27.81 parts; mercury, 46.41 parts.

Yellow Dipping Metal.—Copper, 32 lbs.; 6 to 7 oz. zinc to every lb. of copper.

Quick Bright Dipping Acid, for Brass which has been Ormolued.—Sulphuric acid, 1 gal.; nitric acid, 1 gal.

Dipping Acid.—Sulphuric acid, 12 lbs.; nitric acid, 1 pint; nitre, 4 lbs.; soot, 2 handfuls; brimstone, 2 oz. Pulverize the brimstone, and soak it in water an hour. Add the nitric acid last.

Good Dipping Acid for Cast Brass.—Sulphuric acid, 1 qt.; nitre, 1 qt.; water, 1 qt. A little muriatic acid may be added or omitted.

Dipping Acid.—Sulphuric acid, 4 gals.; nitric acid, 2 gals.; saturated solution of sulphate of iron (copperas,) 1 pint; solution of sulphate of copper, 1 qt.

Ormolu Dipping Acid, for Sheet Brass.—Sulphuric acid, 2 gals.; nitric acid, 1 pt.; muriatic acid, 1 pt.; water, 1 pint.; nitre, 12 lbs. Put in the muriatic acid last, a little at a time, and stir the mixture with a stick.

Ormolu Dipping Acid, for Sheet or Cast Brass.—Sulphuric acid, 1 gal.; sal ammoniac, 1 oz.; sulphur (in flour,) 1 oz.; blue vitriol, 1 oz.; saturated solution of zinc in nitric acid, mixed with an equal quantity of sulphuric acid, 1 gal.

To Prepare Brass Work for Ormolu Dipping.—If the work is oily, boil it in lye; and if it is finished work, filed or turned, dip it in old acid, and then it is ready to be ormolued; but if it is unfinished, and free from oil, pickle it in strong sulphuric acid, dip in pure nitric acid, and then in the old acid, after which it will be ready for ormoluing.

To Repair Old Nitric Acid Ormolu Dips.—If the work after dipping appears coarse and spotted, add vitriol till it answers the purpose. If the work after dipping appears too smooth, add muriatic acid and nitre till it gives the right appearance.

The other ormolu dips should be repaired according to the receipts, putting in the proper ingredients, to strengthen them. They should not be allowed to settle, but should be stirred often while using.

Tinning Acid, for Brass or Zinc.—Muriatic acid, 1 qt.; zinc, 6 oz. To a solution of this, add water, 1 qt; sal ammoniac, 2 oz.

Vinegar Bronze, for Brass.—Vinegar, 10 gals.; blue vitriol, 3 lbs.; muriatic acid, 3 lbs.; corrosive sublimate, 4 grs.; sal ammoniac, 2 lbs.; alum, 8 oz.

Directions for making Lacquer.—Mix the ingredients, and let the vessel containing them stand in the sun, or in a place slightly warmed, three or four days, shaking it frequently till the gum is dissolved, after which, let it settle from twenty-four to forty-eight hours, when the clear liquor may be poured off for use. Pulverized glass is sometimes used, in making lacquer, to carry down the impurities.

Lacquer, for Dipped Brass.—Alcohol, proof specific gravity not less than 95-100ths, 2 gals.; seed lac, 1 lb.; gum copal 1 oz.; English saffron, 1 oz.; annotto, 1 oz.

Lacquer for Bronzed Brass.—To one pint of the above lacquer, add gamboge, 1 oz.; and, after mixing it, add an equal quantity of the first lacquer.

Deep Gold-Colored Lacquer. — Best alcohol, 40 oz.; Spanish annotto, 8 grs.; turmeric, 2 drs.; shellac, ½ oz.; red sanders, 12 grs.; when dissolved, add spirits of turpentine, 30 drops.

Gold-Colored Lacquer, for Brass not Dipped.—Alcohol, 4 gals.; turmeric, 3 lbs.; gamboge, 3 oz.; gum sanderach, 7 lbs; shellac, 1½ lbs.; turpentine varnish, 1 pint.

Gold-Colored Lacquer, for Dipped Brass.—Alcohol, 36 oz.; seed lac, 6 oz.; amber, 2 oz.; gum gutta, 2 oz.; red sandal wood, 24 grs.; dragon's blood, 60 grs.; oriental saffron, 36 grs.; pulverized glass, 4 oz.

Gold Lacquer, for Brass. — Seed lac, 6 oz.; amber or copal, 2 oz.; best alcohol, 4 gals.; pulverized glass, 4 oz.; dragon's blood, 40 grs.; extract of red sandal wood obtained by water, 30 grains.

Lacquer for Dipped Brass.—Alcohol, 12 gals.; seed lac, 8 lbs.; turmeric, 1 lb. to a gallon of the above mixture; Spanish saffron, 4 oz. The saffron is to be added for bronze work.

Good Lacquer.—Alcohol, 8 oz.; gamboge, 1 oz.; shellac, 3 oz.; annotto, 1 oz.; solution of 3 oz. of seed lac in 1 pint of alcohol; when dissolved, add ½ oz. Venice turpentine, ¼ oz. dragon's blood, will make it dark; keep it in a warm place four or five days.

To Bronze Iron Castings. — Cleanse thoroughly, and afterwards immerse in a solution of sulphate of copper, when the castings will acquire a coat of the latter metal. They must be then washed in water.

Antique Bronze Paint.—Sal-ammoniac, 1 oz.; cream tartar, 3 oz.; common salt, 6 oz. Dissolve in 1 pint hot water, then add 2 oz. of nitrate of copper dissolved in ½ pint water, mix well, and apply it repeatedly to the article, in a damp situation, with a brush

To Fill Holes in Castings.—A mixture of putty and black lead is good, but a better method is a metal that expands in cooling: Lead, 9 parts; antimony, 2; and bismuth 1. To be melted and poured in.

Pale Lacquer for Tin Plate.—Best alcohol, 8 oz.; turmeric, 4 drs.; hay saffron, 2 scs.; dragon blood, 4 scs.; red sanders, 1 sc.; shellac, 1 oz. ; gum sanderach, 2 drs. ; gum mastic, 2 drs. ; Canada balsam, 2 drs.; when dissolved, add spirits of turpentine, 80 drops.

Red Lacquer, for Brass. — Alcohol, 8 gallons; dragon's blood, 4 lbs.; Spanish annotto, 12 pounds; gum sanderach, 13 pounds; turpentine, 1 gallon.

Pale Lacquer, for Brass.—Alcohol, 2 gals.; Cape aloes, cut small, 3 oz.; pale shellac, 1 lb.; gamboge, 1 oz.

Bronze Dip.—Sal-ammoniac, 1 oz.; salt of sorrel (binoxolate of potash), ¼ oz. dissolved in vinegar.

Parisian Bronze Dip.—Sal-ammoniac, ½ oz.; common salt, ½ oz.; spirits of hartshorn, 1 oz. dissolved in an English quart of vinegar. A good result will be obtained by adding ½ oz. of sal-ammoniac, instead of the spirits of hartshorn. The piece of metal, being well cleaned; is to be rubbed with one of these solutions, then dried by friction with a flesh brush.

Best Lacquer for Brass.—Alcohol, 4 gals.; shellac, 2 lbs.; amber gum, 1 lb.; copal, 20 oz.; seed lac, 3 lbs.; saffron, to color; pulverized glass, 8 oz.

Color for Lacquer.—Alcohol, 1 qt.; annotto, 4 oz.

Lacquer for Philosophical Instruments. — Alcohol, 80 oz.; gum gutta, 3 oz.; gum sandarac, 8 oz.; gum elemi, 8 oz.; dragon's blood, 4 oz.; seed lac, 4 oz.; terra merita, 3 oz.; saffron, 8 grs.; pulverized glass, 12 oz.

Brown Bronze Dip.—Iron scales, 1 lb.; arsenic, 1 oz.; muriatic acid, 1 lb.; zinc (solid), 1 oz. Let the zinc be kept in only while it is in use.

Green Bronze Dip.—Wine vinegar, 2 qts.; verditer green, 2 oz.; sal ammoniac, 1 oz.; salt, 2 oz.; alum, ½ oz. French berries, 8 oz.; boil the ingredients together.

Aqua-fortis Bronze Dip.—Nitric acid, 8 oz.; muriatic acid, 1 qt.; sal-ammoniac, 2 oz.; alum, 1 oz.; salt, 2 oz.; water, 2 gals. Add the salt after boiling the other ingredients, and use it hot.

Olive Bronze Dip, for Brass.—Nitric acid, 3 oz.; muriatic acid, 2 oz.; add titanium or palladium; when the metal is dissolved, add 2 gals. pure soft water to each pint of the solution.

Brown Bronze Paint, for Copper Vessels.—Tincture of steel, 4 oz.; spirits of nitre, 4 oz.; essence of dendi, 4 oz.; blue vitriol, 1 oz.; water, ½ pint. Mix in a bottle; apply it with a fine brush, the vessel being full of boiling water; varnish after the application of the bronze.

Bronze for All Kinds of Metal.—Muriate of ammonia (sal-ammoniac), 4 drs.; oxalic acid, 1 dr.; vinegar, 1 pint. Dissolve the oxalic acid first; let the work be clean; put on the bronze with a brush, repeating the operation as many times as may be necessary.

Bronze Paint, for Iron or Brass.—Chrome green, 2 lbs.; ivory black, 1 oz.; chrome yellow, 1 oz.; good Japan, 1 gill: grind all together, and mix with linseed oil.

For Tinning Brass.—Water, 2 pails full; cream of tartar, ½ lb.; salt, ½ pint.

Shaved or Grained Tin.—Boil the work in the mixture, keeping it in motion during the time of boiling.

Silvering by Heat.—Dissolve 1 oz. of silver in nitric acid; add a small quantity of salt; then wash it, and add sal ammoniac, or 6 oz. of salt and white vitriol; also, ¼ oz. of corrosive sublimate;

rub them together till they form a paste; rub the piece which is to be silvered with the paste; heat it till the silver runs, after which dip it in a weak vitriol pickle to clean it.

Mixture for Silvering.—Dissolve 2 oz. of silver with 3 grs. of corrosive sublimate; add tartaric acid, 4 lbs.; salt, 8 qts.

Separate Silver from Copper.—Mix Sulphuric acid, 1 part; nitric acid, 1 part; water, 1 part; boil the metal in the mixture till it is dissolved, and throw in a little salt to cause the silver to subside.

Chinese White Copper.—Copper, 40.4; nickel, 31.6; zinc, 25.4; and iron, 2.6 parts.

Bath Metal.—Brass, 32; and zinc, 9 parts.

Speculum Metal.—Copper, 6; tin, 2; and arsenic, 1 part. Or copper, 7; zinc, 3; and tin, 4 parts.

Britannia Metal.—Brass, 4; tin, 4 parts; when fused, add bismuth, 4; and antimony, 4 parts. This composition is added at discretion to melted tin.

Jeweler's Soldering Fluid.—Take alcohol, and add to it all the chloride of zinc it will dissolve, and it is ready for use. A good *soft solder* for repairing,—equal quantities of tin, and lead from tea-boxes.

Tinman's Solder.—Lead, 1; tin, 1 part.

Pewterer's Solder.—Tin, 2; lead, 1 part.

Common Pewter.—Tin, 4; lead, 1 part.

Best Pewter.—Tin, 100; antimony, 17 parts.

Queen's Metal.—Tin, 9; antimony, 1; bismuth, 1; lead, 1 part.

Tinning Iron.—Cleanse the metal to be tinned; and rub with a coarse cloth, previously dipped in hydrochloric acid (muriatic acid,) and then rub on French putty with the same cloth. French putty is made by mixing tin filings with mercury.

Tinning.—1. Plates or vessels of brass or copper boiled with a solution of stannate of potassa, mixed with turnings of tin, become, in the course of a few minutes, covered with a firmly attached layer of pure tin. 2. A similar effect is produced by boiling the articles with tin-filings and caustic alkali, or cream of tartar. In the above way, chemical vessels made of copper or brass may be easily and perfectly tinned.

New Tinning Process.—The articles to be tinned are first covered with dilute sulphuric acid, and, when quite clean, are placed in warm water, then dipped in a solution of muriatic acid, copper, and zinc, and then plunged into a tin bath to which a small quantity of zinc has been added. When the tinning is finished, the articles are taken out and plunged into boiling water. The operation is completed by placing them in a very warm sand-bath. This last process softens the iron.

Kustitien's Metal for Tinning.—Malleable iron, 1 lb., heat to whiteness; add 5 oz. regulus of antimony, and Molucca tin, 24 pounds.

Watchmaker's Brass.—Copper, 1 part; zinc, 2 parts.

German Brass.—Copper, 1 part; zinc, 1 part.

Brass for Heavy Castings.—Copper, 6 to 7 parts; tin, 1 part; zinc, 1 part.

Yellow Brass.—(FOR CASTINGS).—1. Copper, 61.6 parts; zinc, 35.3 parts; lead, 2.9 parts; tin, 0.2 parts. 2. BRASS OF JEMAPPES.—Copper, 64.6 parts; zinc, 33.7 parts; lead, 1.4 parts; tin, 0.2 parts. 3. SHEET BRASS OF STOLBERG NEAR AIX-LA-CHAPELLE.—Copper, 64.8 parts; zinc, 32.8 parts; lead, 2.0 parts; tin, 0.4 parts. 4. D'ARCET'S BRASS FOR GILDING—Copper, 63.70 parts; zinc, 33.55 parts; lead, 0.25 parts; tin, 2.50 parts. 5. ANOTHER.—Copper, 64.45 parts; zinc, 32.44 parts; lead, 2.86 parts; tin, 0.25 parts. 6. SHEET BRASS OF ROMILLY.—Copper, 70.1 parts; zinc, 29.9 parts. 7. ENGLISH BRASS WIRE.—Copper, 70.29 parts; zinc, 29.26 parts; lead, 0.28 parts; tin, 0.17 parts. 8. AUGSBURG BRASS WIRE.—Copper, 71.89 parts; zinc, 27.63 parts; tin, 0.85 parts.

Red Brass for Gilt Articles.—1. Copper, 82.0 parts; zinc, 18.0 parts; lead, 1.5 parts; tin, 3.0 parts. 2. ANOTHER.—Copper, 82 parts; zinc, 18 parts; lead, 3 parts; tin, 1 part. 3. ANOTHER.—Copper, 82.3 parts; zinc, 17.5 parts; tin, 0.2 parts. 4. FRENCH TOMBAC FOR SWORD HANDLES.—Copper, 80 parts; zinc, 17 parts; tin, 3 parts. 5. FOR PARISIAN ORNAMENTS.—Copper, 85 parts; zinc, 15 parts; tin, a trace. 6. USED FOR GERMAN ORNAMENTS.—Copper, 85.3 parts; zinc, 14.7 parts. 7. CHRYSOCHALK.—Copper, 90.0 parts; zinc, 7.9 parts; lead, 1.6 parts. 8. RED TOMBAC FROM PARIS.—Copper, 92 parts; zinc, 8 parts.

Compositions.—1. FOR STRONG PUMPS, &C.—Copper, 1 lb.; zinc, ½ oz.; tin, 1½ oz. 2. FOR TOOTHED WHEELS.—Copper, 1 lb.; brass, 2 oz.; tin, 2 oz. 3. Copper, 1 lb.; brass, 2 oz.; tin, 1¾ oz. 4 FOR TURNING WORK.—Copper, 1 lb.; brass, 1½ oz.; tin, 2 oz. 5. FOR NUTS OF COARSE THREADS AND BEARINGS.—Copper, 1 lb.; brass, 1½ oz., tin, 2¼ oz. 6. FOR BEARINGS TO SUSTAIN GREAT WEIGHTS.—Copper, 1 lb.; zinc, ½ oz.; tin, 2½ oz. 7. PEWTERER'S TEMPER.—Tin, 2 lb.; copper, 1 lb. Used to add in small quantities to tin. 8. HARD BEARINGS FOR MACHINERY.—Copper, 1 lb.; tin, 2 oz. 9. VERY HARD DITTO.—Copper, 1 lb.; tin, 2½ oz.

Babbitt Metal.—Copper, 4 lbs.; regulus of antimony, 8 lbs.; Banca tin, 96 lbs.

Fenton's Anti-Friction Metal.—Grain zinc, 7½ lbs.; purified zince, 7½ lbs.; antimony, 1 lb.

Anti-Friction Alloy for Journal Boxes.—Zinc, 17 parts; copper, 1 part; antimony, 1½ parts. This possesses unsurpassable anti-friction qualities, and does not require the protection of outer casings of a harder metal.

Babbitt Metal.—Block tin, 8 lbs.; antimony, 2 lbs.; copper, 1 lb. If the metal be too hard, it may be softened by adding some lead.

Alloy for Journal Boxes.—The best alloy for journal boxes is composed of copper, 24 lbs.; tin, 24 lbs.; and antimony, 8 lbs. Melt the copper first, then add the tin, and lastly the antimony. It should be first run into ingots, then melted, and cast in the form required for the boxes.

To Gild Steel.—Pour some of the ethereal solution of gold into a wine glass, and dip into it the blade of a new penknife, razor, lancet, &c.; withdraw the instrument, and allow the ether to evaporate. The blade will then be found covered with a beautiful coat of gold. The blade may be moistened with a clean rag, or a small piece of very dry sponge, dipped into the ether; and the same effects will be produced.

To Weld Cast Iron.—Take of good clear white sand, 3 parts; refined solton, 1 part; fosterine, 1 part; rock salt, 1 part: mix all together. Take 2 pieces of cast iron, heat them in a moderate charcoal fire, occasionally taking them out while heating, and dipping them into the composition, until they are of a proper heat to weld; then at once lay them on the anvil, and gently hammer them together, and, if done carefully by one who understands welding iron, you will have them nicely welded together. One man prefers heating the metal, then cooling it in the water of common beans, and heat it again for welding.

To Galvanize Iron.—Cleanse the surface of the iron perfectly by the joint action of dilute acid and friction, plunge it into a bath of melted zinc covered with sal-ammoniac, and stir it about till it be alloyed superficially with this metal. When the metal thus prepared is exposed to humidity, the zinc oxidizes slowly by a galvanic action, and protects the iron within from rust; whereby the outer surface remains for a long time perfectly white, in circumstances under which iron tinned in the usual way would be corroded with rust.

Muntz Metal for Ships.—Best selected copper, 60 parts; best zinc, 40 parts: melt together in the usual manner, and roll into sheets of suitable thickness. This composition resists oxidation from exposure to sea water, and prevents the adhesion of barnacles.

Tempering Saws, &c.—The usual method of tempering saws is to heat, and then dip them in oil. This process is slow, costly, and laborious. It is also disadvantageous, because the saws become warped, and require to be hammered up straight again by hand. A late improvement consists in tempering and straightening the saws at one operation. This is done by heating the saws to the proper degree, and then pressing them with a sudden and powerful stroke between two surfaces of cold iron. A drop press is employed for the purpose. The mechanism is quite simple and inexpensive. Its use effects an important economy in the manufacture of nearly all kinds of saws, and also improves their quality.

Silvering Shells.—Silver leaf and gum water a sufficient quantity; grind to a proper thickness, and cover the inside of the shells.

For a *gold color*, grind up gold-leaf with gum water, and apply to the inside of the shells.

Liquid Foil for Silvering Glass Globes, &c.—Lead, 1 part; tin, 1 part; bismuth, 1 part: melt, and, just before it sets, add mercury, 10 parts. Pour this into the globe, and turn it rapidly round.

To Soften Iron or Steel.—Either of the following methods will make iron or steel as soft as lead:—1. Anoint it all over with tallow, temper it in a gentle charcoal fire, and let it cool of itself. 2. Take a little clay, cover your iron with it, temper in a charcoal fire. 3. When the iron or steel is red hot, strew hellebore on it. 4. Quench the iron or steel in the juice or water of common beans.

Tempering.—The article, after being completed, is hardened by being heated gradually to a bright red, and then plunged into cold water: it is then tempered by being warmed gradually and equably, either over a fire, or on a piece of heated metal, till of the color corresponding to the purpose for which it is required, as per table below; when it is again plunged into water.

CORRESPONDING TEMPERATURE.

A very pale straw,	430	Lancets.	All kinds of wood tools.
Straw,	450	Razors.	
Darker Straw	470	Penknives.	All kinds of wood tools.
Yellow,	490	Scissors.	Screw taps.
Brown yellow,	500	Hatchets, chipping chisels,	
Slightly tinged purple,	520	Saws.	
Purple,	530	All kinds of percussive tools.	
Dark purple,	550	Springs.	
Blue,	570	Springs.	
Dark blue,	600	Soft for saws.	

Cast Iron Cement.—Clean borings or turnings of cast iron, 16; sal ammoniac, 2; flour of sulphur, 1 part; mix them well together in a mortar; and keep them dry. When required for use, take of the mixture, 1; clean borings, 20 parts; mix thoroughly, and add a sufficient quantity of water. A little grindstone dust added improves the cement.

Cement for Steam Pipe Joints, Etc., with Faced Flanges.—White lead, mixed, 2; red lead, dry, 1 part; grind, or otherwise mix them to a consistence of thin putty; apply interposed layers with one or two thicknesses of canvas, or gauze wire, as the necessity of the case may be.

Crucibles.—The best crucibles are made from a pure fire clay, mixed with finely ground *cement* of old crucibles, and a portion of black lead or graphite: some pounded coke may be mixed with the plumbago. The clay should be prepared in a similar way as for making pottery ware: the vessels, after being formed, must be slowly dried, and then properly baked in the kiln.

BLACK LEAD CRUCIBLES are made of 2 parts graphite, and 1 of fire-clay, mixed with water into a paste, pressed in moulds, and well dried, but not baked hard in the kiln. This compound forms excellent small or portable furnaces.

To Purify Gas.—The purifier is to be filled with milk of lime, made by mixing 1 part of slacked lime with 25 parts of water. A very great improvement in the purification of gas has been effected by Mr. Statter, of England, by the employment of hydrated clay along with the lime employed for this purpose. Hydrated clay unites with the ammonia of the gas as with a base, and, at the same time, with its sulphuret of carbon as an acid, and thus removes both of these noxious impurities from the gas exposed to its influence. It assists also, in conjunction with the lime, in removing tarry vapor and other impurities from the gas. The illuminating power of the gas is positively increased by the clay purification from 22 to 33⅓ per cent.

To Joint Lead Plates.—The joints of lead plates for some purposes are made as follows: The edges are brought together, hammered down into a sort of channel cut out of wood, and secured with a few tacks. The hollow is then scraped clean with a scraper, rubbed over with candle grease, and a stream of hot lead is poured into it, the surface being afterwards smoothed with a red hot plumber's iron.

To Joint Lead Pipes.—Widen out the end of one pipe with a taper wood drift, and scrape it clean inside; scrape the end of the other pipe outside a little tapered, and insert it in the former, then solder it with common lead solder as before described; or, if it requires to be strong, rub a little tallow over, and cover the joint with a ball of melted lead, holding a cloth (2 or 3 plies of greased bedtick) on the under side; and smoothing over with it and the plumber's iron.

Composition used in Welding Cast Steel.—Borax, 10; sal ammoniac, 1 part; grind or pound them roughly together; then fuse them in a metal pot over a clear fire, taking care to continue the heat until all spume has disappeared from the surface. When the liquid appears clear, the composition is ready to be poured out to cool and concrete; afterwards being ground to a fine powder it is ready for use. To use this composition, the steel to be welded is raised to a heat which may be expressed by "bright yellow;" it is then dipped among the welding powder, and again placed in the fire until it attains the same degree of heat as before; it is then ready to be placed under the hammer.

To prevent Deposits of Lime in Boilers.—Throw into the tank or reservoir from which your boiler is fed, a quantity of rough bark, in the piece, such as tanners use, sufficient to turn the water of a brown color; if you have no tank, put into the boiler from a half to a bushel of ground bark when you blow off; repeat every month, using only half the quantity after the first time.

Scaling Cast Iron.—Vitriol, 1 part; water, 2 parts; mix and lay on the diluted vitriol with some old cloth in the form of a brush, enough to wet the surface well; after 8 or 10 hours, wash off with water, when the hard, scaly surface will be completely removed.

Varnish, for Smooth Moulding Patterns.—Alcohol, 1 gallon; shellac, 1 lb.; lamp or ivory black, sufficient to color it.

Cast Iron Ornaments are rendered susceptible of being finished with a scraper, where they cannot be reached with files, after having the above liquid applied to them.

Iron Lustre is obtained by dissolving a piece of zinc with muriatic acid, and mixing the solution with spirit of tar, and applying it to the surface of iron.

To Melt Steel as Easily as Lead.—This apparent impossibility is easily performed by heating the bar of iron or steel red hot, and then touching it with a roll of brimstone, when the metal will drop like water.

Patent Lubricating Oil.—Water, 1 gal.; clean tallow, 3 lbs.; palm oil, 10 lbs.; common soda, ½ lb. Heat the mixture to about 210° F.; stir well till it cools down to 70° F., when it is fit for use.

Black Having a Polish for Iron.—Pulverized gum asphaltum, 2 lbs.; gum benzoin, ¼ lb.; spirits of turpentine, 1 gal.; to make quick, keep in a warm place, and shake often; shade to suit with finely ground ivory black. Apply with a brush. And it ought to be used on iron exposed to the weather as well as on inside work, desiring a nice appearance or polish. Or:

Varnish for Iron.—Asphaltum, 8 lbs.; melt in an iron kettle, slowly adding boiled linseed oil, 5 gals.; litharge, 1 lb., and sulphate of zinc, ½ lb.; continuing to boil for 3 hours; then add dark gum amber, 1½ lbs.; and continue to boil 2 hours longer. When cool, reduce to a proper consistence to apply with a brush, with spirits of turpentine.

To Restore Burnt Steel, and improve Poor Steel.—Borax, 3 oz.; sal ammoniac, 8 oz.; prussiate of potash, 3 oz.; blue clay, 2 oz.; resin, 1½ lbs.; water, 1 gill; alcohol, 1 gill. Put all on the fire, and simmer till it dries to a powder. The steel is to be heated, and dipped into this powder, and afterwards hammered.

Composition to toughen Steel.—Resin, 2 lbs.; tallow, 2 lbs.; black pitch, 1 lb.; melt together, and dip in the steel when hot.

Burglar and Drill Proof Diamond Chill.—Take 1 gal. urine, and add to it 1 oz. borax and 1 oz. salt.

How to Re-cut Old Files and Rasps.—Dissolve 4 oz. of saleratus in 1 qt. of water, and boil the files in it for half an hour; then remove, wash and dry them. Now have ready, in a glass or stone-ware vessel, 1 qt. of rain water, into which you have slowly added 4 oz. of best sulphuric acid, and keep the proportions for any amount used. Immerse the files in this preparation for from six to twelve hours, according to fineness or coarseness of the file; then remove; wash them clean, dry quickly, and put a little sweet oil on them to cover the surface. If the files are coarse, they will need to remain in about twelve hours, but for fine files six to eight hours is sufficient. This plan is applicable to blacksmiths', gunsmiths', tin-

ners', coppersmiths', and machinists' files. Copper and tin workers will only require a short time to take the articles out of their files, as the soft metals with which they become filled are soon dissolved. Blacksmiths' and saw-mill files require full time. Files may be recut three times by this process. The liquid may be used at different times if required. Keep away from children, as it is poisonous.

Substitute for Borax.—Copperas, 2 oz.; saltpetre, 1 oz.; common salt, 6 oz.; black oxide of manganese, 1 oz.; prussiate of potash, 1 oz.; all pulverized and mixed with 3 lbs. nice welding sand, and use the same as you would sand. High-tempered steel can be welded with this at a lower heat than is required for borax.

Tempering Liquid.—To 6 qts. soft water put in corrosive sublimate, 1 oz.; common salt, 2 handfuls; when dissolved, it is ready for use. The first gives toughness to the steel, while the latter gives the hardness. Be careful with this preparation, as it is a dangerous poison.

Another.—Salt, ½ tea-cup; saltpetre, ½ oz., alum, pulverized, 1 teaspoon; soft water, 1 gallon; never heat over a cherry red, nor draw any temper.

Another.—Saltpetre, sal-ammoniac and alum, of each 2 oz.; salt, 1½ lbs.; water, 3 gallons, and draw no temper

Another.—Saltpetre and alum each, 2 oz.; sal-ammoniac, ½ oz.; salt, 1½ lbs.; soft water, 2 gallons. Heat to a cherry red, and plunge in, drawing no temper.

Another.—Water, 3 gallons; salt, 2 qts.; sal-ammoniac and saltpetre, of each 2 oz.; ashes from white-ash bark, 1 shovel, which causes the steel to scale white and smooth as silver. Do not hammer too cold, to avoid flaws; do not heat too high, which opens the pores of the steel; and do not heat more than one or two inches of the steel at a time while tempering, if you wish the hardness and toughness of the steel to be of the first quality.

To Improve Poor Iron.—Black oxide of manganese, 1 part; copperas and common salt, 4 parts each; dissolve in soft water, and boil till dry; when cool, pulverize and mix quite freely with nice welding sand. When you have poor iron which you cannot afford to throw away, heat it, and roll it in this mixture; working for a time, reheating, &c., will soon free it from all impurities, which is the cause of its rottenness. By this process you can make good horse-nails out of common iron.

Case Hardening for Iron.—Case iron may be case-hardened by heating to a red heat, and then rolling it in a composition composed of equal parts of prussiate of potash, sal-ammoniac, and saltpetre, all pulverized and thoroughly mixed. This must be got to every part of the surface; then plunged, while yet hot, into a bath containing 2 oz. prussiate of potash, and 4 oz. sal-ammoniac to each gallon of cold water.

For Malleable Iron.—Put the articles in an iron box, and stratify them among animal carbon, that is, pieces of horns, hoofs,

skins or leather, just sufficiently burned to be reduced to powder. Lute the box with equal parts of sand and clay; then place it in the fire, and keep at a light red heat for a length of time proportioned to the depth of steel required, when the contents of the box are emptied into water.

Another for Wrought Iron.—Take the prussiate of potash, finely pulverized, and roll the article in it, if its shape admits of it; if not, sprinkle the powder upon it freely while the iron is hot.

To Soften Cast Iron for Drilling.—Heat to a cherry red, having it lie level in the fire; then with a pair of cold tongs put on a piece of brimstone, a little less in size than the hole to be when drilled, and it softens entirely through the piece; let it lie in the fire until a little cool, when it is ready for drilling.

To Temper Springs.—For tempering cast-steel trap springs, all that is necessary is to heat them in the *dark*, just so that you can see that they are red; then cool them in luke-warm water. You can observe a much lower degree of heat in the dark than by daylight, and the low heat and warm water give the desired temper.

To Mend Broken Saws.—Pure silver, 19 parts; pure copper, 1 part; pure brass, 2 parts; all to be filed into powder, and thoroughly mixed; place the saw level on the anvil, broken edges in contact, and hold them so; now put a small line of the mixture along the seam, covering it with a larger bulk of powdered charcoal; now with a spirit lamp and a jeweller's blow-pipe, hold the coal dust in place, and blow sufficient to melt the solder mixture; then with a hammer set the joint smooth, and file away any superfluous solder, and you will be surprised at its strength; the heat will not injure the temper of the saw.

Writing Inscriptions on Metals.—Take ½ lb. nitric acid and 1 oz. muriatic acid. Mix, shake well together, and it is ready for use. Cover the place you wish to mark with melted bees-wax; when cold, write your inscription plainly in the wax clear to the metal with a sharp instrument; then apply the mixed acids with a feather, carefully filling each letter. Let it remain from one to ten minutes, according to appearance desired; then throw on water, which stops the process, and remove the wax.

Black Varnish for Iron Work.—Asphaltum, 1 lb.; lampblack, ¼ lb.; resin, ½ lb.; spirits turpentine, 1 qt.; linseed oil, just sufficient to rub up the lampblack with before mixing it with the others. Apply with a camel's hair brush.

To Petrify Wood.—Gem salt, rock alum, white vinegar, chalk and peebles powder, of each an equal quantity. Mix well together. If, after the ebullition is over, you throw into this liquid any wood or porous substance, it will petrify it.

The Finest Bronze.—Put in a clean crucible 7 lbs. copper, melt, then add 3 lbs. zinc, afterwards 2 lbs. tin. In order to gild polished steel or polished iron, dip the article into an ethereal solution of

gold, withdraw from the solution, and the ether flies off and leaves the gold deposited.

Soft Cement, for Steam Boilers, Steam Pipes, &c.—Red or white lead, in oil, 4; iron borings, 2 to 3 parts.

Hard Cement.—Iron borings and salt water, and a small quantity of sal ammoniac with fresh water.

Black Varnish, for Coal Buckets.—Asphaltum, 1 lb.; lampblack, ¼ lb.; resin, ½ lb.; spirits of turpentine, 1 qt. Dissolve the asphaltum and resin in the turpentine; then rub the lampblack with linseed oil, only sufficient to form a paste, and mix with the others. Apply with a brush.

Soldering Fluid.—Take 2 oz. muriatic acid; add zinc till bubbles cease to rise; add ½ teaspoonful of sal ammoniac and 2 oz. of water. Damp the part you wish to solder with this fluid; lay on a small piece of solder, and with a piece of hot iron or soldering iron solder the part.

Japan Flow for Tin.—All Colors.—Gum sandarac, 1 lb.; balsam of fir, balsam of Tolu, and acetate of lead, of each, 2 oz.; linseed oil, ½ pint; spirits of turpentine, 2 qts. Put all into a suitable kettle, except the turpentine, over a slow fire, at first; then raise to a higher heat till all are metled; now take from the fire, and, when a little cool, stir in the spirits of turpentine, and strain through a fine cloth. This is transparent; but by the following modifications any or all the various colors are made from it.

2. Black.—Prussian blue, 1 oz.; asphaltum, 2 oz.; spirits of turpentine, ½ pint. Melt the asphaltum in the turpentine; rub up the blue with a little of it; mix well, and strain; then add the whole to 1 pint of the *first*, above.

3. Blue.—Indigo, and Prussian blue, both finely pulverized, of each ½ oz.; spirits of turpentine, 1 pint. Mix well, and strain. Add of this to one pint of the *first* until the color suits.

4. Red.—Take spirits of turpentine, ½ pt.; add cochineal, ½ oz.; let stand 15 hours, and strain. Add of this to the *first* to suit the fancy. If carmine is used instead of cochineal, it will make a fine color for watch hands.

5. Yellow.—Take 1 oz. of pulverized root of curcuma, and stir of it into 1 pt. of the *first* until the color pleases you; let stand a few hours, and strain.

6. Green.—Mix equal parts of the blue and yellow together, then mix with the *first* until it suits the fancy.

7. Orange.—Mix a little of the red with more of the yellow, and then with the *first* as heretofore, until pleased.

8. Pink.—Mix a little of the blue to more in quantity of the red, and then with the *first* until suited. Apply with a brush.

Transparent Blue for Iron or Steel.—Demar varnish, ½ gal.; fine ground Prussian blue, ½ oz.; mix thoroughly. Makes a splendid appearance. Excellent for blueing watch hands.

To Tin Copper Stew Dishes, etc.—Wash the surface of the article to be tinned with sulphuric acid, and rub the surface well, so as to have it smooth and free of blackness caused by the acid; then sprinkle calcined and finely pulverized sal-ammoniac upon the surface, holding it over a fire, when it will be sufficiently hot to melt a bar of solder which is to be rubbed over the surface: any copper dish or vessel may be tinned in this way.

To Copper the Surface of Iron, Steel, or Iron Wire.—Have the article perfectly clean, then wash with the following solution, and it presents at once a coppered surface. Rain water, 3 lbs.; sulphate of copper, 1 lb.

To Tin Iron for Soldering, &c.—Take any quantity of muriatic acid, and dissolve all the zinc in it that it will cut; dilute it with one-fourth as much soft water as of acid, and it is ready for use. Rub this liquid on iron; and no matter how rusty it may be, it will brighten it up so that solder will readily adhere to it; or the above copper solution may be applied, giving it a coat of copper.

Gold Lacquer for Tin.—TRANSPARENT, ALL COLORS.—Alcohol in a flask, ½ pt.; add gum shellac, 1 oz.; turmeric, ½ oz.; red sanders, ¼ oz. Set the flask in a warm place, shake frequently for 12 hours or more, then strain off the liquor, rinse the bottle, and return it, corking tightly for use.

When this varnish is used, it must be applied to the work freely and flowing; and the article must be hot when applied. One or more coats may be laid on, as the color is required more or less light or deep. If any of it should become thick from evaporation, at any time, thin it with alcohol. And by the following modifications, all the variоus colors are obtained.

2. ROSE COLOR.—Proceed as above, substituting ¼ oz. of finely ground best lake in place of the turmeric.

3. BLUE.—The blue is made by substituting pulverized Prussian blue, ½ oz., in place of the turmeric.

4. PURPLE.—Add a little of the blue to the *first.*

5. GREEN.—Add a little of the rose-color to the *first.*

Crystallized Tin Plate.—The figures are more or less beautiful and diversified, according to the degree of heat, and relative dilution of the acid. Place the tin-plate, slightly heated, over a tub of water, and rub its surface with a sponge dipped in a liquor composed of four parts of aquafortis, and two of distilled water, holding one part of common salt or sal ammoniac in solution. Whenever the crystalline spangles seem to be thoroughly brought out, the plate must be immersed in water, 'washed either with a feather or a little cotton (taking care not to rub off the film of tin that forms the feathering), forthwith dried with a low heat, and coated with a lacker varnish, otherwise it loses its lustre in the air. If the whole surface is not plunged at once in cold water, but if it be partially cooled by sprinkling water on it, the crystallization will be finely variegated with large and small figures. Similar

results will be obtained by blowing cold air through a pipe on the tinned surface, while it is just passing from the fused to the solid state.

To Crystallize Tin.—Sulphuric acid, 4 oz.; soft water, 2 to 3 oz., according to strength of the acid; salt, 1¼ oz; mix; heat the tin hot over a stove, then with a sponge apply the mixture, then wash off directly with clean water. Dry the tin, and varnish with demar varnish.

Improved Tinning Flux.—Muriatic acid, 1 lb.; put into it all the zinc it will dissolve and 1 oz. sal ammoniac, and it is ready for use.

To Clean and Polish Brass.—Oil of vitriol, 1 oz.; sweet oil, ½ gill; pulverized rotten stone, 1 gill; rain water, 1½ pints; mix all, and shake as used. Apply with a rag, and polish with buckskin or old woolen.

Silvering Powder.—Nitrate of silver and common salt, of each, 30 grs; cream of tartar, 3½ drs. Pulverize finely, mix thoroughly, and bottle for use. Unequalled for polishing copper and plated goods.

Tin Cans.—SIZE OF SHEET, FOR FROM 1 TO 100 GALLONS:

For 1	gallon,	7 by 20 inches.	For 25	gallons,	30 by 56	inches.
3½	"	10 by 28 "	40	"	36 by 63	"
5	"	12 by 40 "	50	"	40 by 70	"
6	"	14 by 40 "	75	"	40 by 84	"
10	"	20 by 42 "	100	"	40 by 98	"
15	"	30 by 42 "				

This includes all the laps, seams, &c., which will be found sufficiently correct for all practical purposes.

To Mend Tinware.—Take a vial two-thirds full of muriatic acid, put into it all the chippings of sheet zinc it will dissolve, then put in a crumb of sal ammoniac, and fill up with water. Wet the place to be mended with this liquid, put a piece of zinc over the hole, and apply a spirit lamp or candle below it, which melts the solder on the tin and causes the zinc to adhere.

Brunswick Black for Grates, &c.—Asphaltum, 5 lbs.; melt, and add boiled oil, 2 lbs.; spirits of turpentine, 1 gal. Mix.

Gas Fitter's Cement.—Mix together rosin, four and a half parts; wax, 1 part; and Venetian red, 3 parts.

Plumber's Cement.—Black resin, 1 part; brick dust, 2 parts; well incorporated by a melting heat. Boiled linseed oil and red lead mixed together into a putty are often used by coppersmiths and engineers to secure joints; the washers of leather or cloth are smeared with this mixture in a pasty state.

Browning for Gun Barrels.—Spirits of nitre, 1 lb.; alcohol, 1 lb.; corrosive sublimate, 1 oz.; mix in a bottle, and cork for use. Directions: Polish the barrel perfect; then rub it with quick-lime with a cloth, which removes grease and dirt; now apply the browning fluid with a clean white cloth; apply one coat, and set it in a warm dark place for from 10 to 20 hours until a red rust forms on

it; then cord it down with a gunmaker's cord, and rub off with a clean cloth. Repeat the process if you wish a dark shade.

Browning for Twist Barrels.—Spirits of nitre, ¾ oz.; tincture of steel, ¾ oz.; or use the unmedicated tincture of iron if the tincture of steel cannot be obtained; black brimstone, ¼ oz.; blue vitriol, ½ oz.; corrosive sublimate, ¼ oz.; nitric acid, 1 drachm; copperas, ¼ oz.; mix with 1½ pints rain water, and bottle for use. This is to be applied the same as the first. It causes the twist of the barrel to be visible after application, a quality which the other liquid does not possess.

Browning Compositions for Gun Barrels.—1. Blue vitriol, 4 oz.; tincture of muriate of iron, 2 oz.; water, 1 quart; dissolve, and add aquafortis and sweet spirits of nitre, of each, 1 oz. 2. Blue vitriol and sweet spirits of nitre, of each, 1 oz.; aquafortis, ½ oz.; water, 1 pint. To be used in the same manner as previously described in this work.

Varnish and Polish for Gun Stocks.—Gum shellac, 10 oz.; gum sandarac, 1 oz.; Venice turpentine, 1 drachm; 98 per cent. alcohol, 1 gallon; shake the jug occasionally for a day or two, and it is ready for use. Apply a few coats of this to your gunstocks, polish by rubbing smooth, and your work is complete.

Hardening and Filling for Fire-proof Safes.—Experience has shown that the fire and burglar proof diamond chill for iron or steel, described in another part of this work, has no superior as a hardening for security in the construction of safes; and, as a non-conductor of heat, we would recommend a filling of plaster of Paris or alum.

Tempering Razors, Cutlery, Saws, &c.—Razors and penknives are too frequently hardened without the removal of the scale arising from the forging. *This practice, which is never done with the best works, cannot be too much deprecated.* The blades are heated in a coke or charcoal fire, and dipped in the water obliquely. In tempering razors, they are laid on their backs upon a clean fire, about half a dozen together, and they are removed one at a time, when the edges, which are as yet thick, come down to a pale straw color. Should the backs accidentally get heated beyond the straw-color, the blades are cooled in water, but not otherwise. Penblades are tempered a dozen or two at a time, on a plate of iron or copper, about 12 inches long, 3 or 4 inches wide, and about ¼ of an inch thick. The blades are arranged close together on their backs, and lean at an angle against each other. As they come down to the temper, they are picked out with small pliers and thrown into water, if necessary; other blades are then thrust forward from the cooler parts of the plate to take their place. Axes, adzes, cold chisels, and other edge tools, in which the total bulk is considerable compared with the part to be hardened, are only partially dipped; they are afterwards let down by the heat of the remainder of the tool; and, when the color indicative of the temper is attained, they

are entirely quenched. With the view of removing the loose scales, or the oxidation acquired in the fire, some workmen rub the objects hastily in dry salt before plunging them in the water, in order to give them a cleaner and brighter face.

Oil, or resinous mixtures of oil, tallow, wax, and resin, are used for many thin and elastic objects, such as needles, fishhooks, steel-pens and springs, which require a milder degree of hardness than is given by water. Gunlock springs are sometimes *fried in oil* for a considerable time over a fire, in an iron tray; the thick parts are then sure to be sufficiently reduced, and the thin parts do not become the more softened from the continuance of the blazing heat.

Saws and springs are generally hardened in various compositions of oil, suet, wax, etc. The saws are heated in long furnaces, and then immersed horizontally and edgeways into a long trough containing the composition. Part of the composition is wiped off the saws with a piece of leather, when they are removed from the trough, and heated one by one, until the grease inflames. This is called "*blazing off*." The composition used by a large saw manufacturer is 2 lbs. suet, and ¼ lb. of beeswax, to every gallon of whale oil; these are boiled together, and will serve for thin works and most kinds of steel. The addition of black resin, about 1 lb. to each gallon, makes it serve for thicker pieces, and for those it refused to harden before; but resin should be added with judgment, or the works will become too hard and brittle.

Silversmith's Stripping Liquid.—Sulphuric acid, 8 parts; nitre, 1 part. Use to re-cover silver on old plated ware.

To Silver Clock Faces, Etc.—Old silver lace, ½ oz.; nitric acid, 1 oz. Boil them over a gentle fire for about 5 minutes in an earthen pot. After the silver is dissolved, take the mixture off, and mix it in a pint of clean water, then pour it into another vessel, free from sediment; then add a tablespoonful of common salt, and the silver will be precipitated in the form of a white powder or curd; pour off the acid, and mix the curd with 2 oz. salt of tartar, and ½ oz. whiting, all together, and it is ready for use. To USE.—Clean your brass or copper plate with rotten stone and a piece of old hat; rub it with salt and water with your hand. Then take a little of the composition on your finger, and rub it over your plate, and it will firmly adhere and completly silver it. Wash it well with water. When dry, rub it with a clean rag, and varnish with this VARNISH FOR CLOCK-FACES: Spirits of wine, 1 pt.; divide into 3 parts, mix one part with gum mastic in a bottle by itself; 1 part spirits, and ½ oz. sandarac in another bottle; and 1 part spirits, and ½ oz. of whitest gum benjamin, in another bottle; mix and temper to your mind. If too thin, some mastic; if too soft, some sandarac or benjamin. When you use it, warm the silvered plate before the fire, and, with a flat camel's hair pencil, stroke it over till no white streaks appear, and this will preserve the silvering for many years.

Watchmaker's Drills.—Drills of the smallest kind are heated in the blue part of the flame of a candle; larger drills are heated with the blow-pipe flame, applied very obliquely, and a little below the point. When very thin, they may be whisked in the air to

cool them; but they are generally thrust into the tallow of a candle or the oil of a lamp. They are tempered either by their own heat, or by immersion in the flame below the point of the tool.

To Reduce Metallic Oxides.—This may be effected by the dry and the moist processes; but the deoxidizing agent of the greatest value to the metallurgist is coal in its several varieties, and the derivative materials yielded by its combustion. When coal is burned in a furnace, the first product of combustion may be considered to be carbonic acid gas; but inasmuch as the latter is readily decomposed by permeating ignited pieces of solid carbon (coke) losing a portion of its oxygen, and becoming carbonic acid gas, we may say that the products of the combustion of coal are, firstly, carbonic acid; secondly, carbonic oxide and carbonic acid; and lastly, carbonic oxide alone. The latter, in combination with heat, is a most powerful deoxidizing agent. Were it not for the production in furnaces of carbonic oxide gas—were it necessary that the solid carbon of the coke should be alone the deoxidizing body—then it follows that every particle of the ore to be reduced must be brought into intimate contact with the reducing body; a process involving more care and trouble than are compatible with large metallurgic operations. The reducing agent being a gas, there is no longer a necessity for that intimate mixture of fuel and ore which would otherwise be necessary. Provided that the gaseous results of combustion are placed under circumstances of readily permeating the ore, the necessities of practice are amply subserved. There is great difference as to the amount of heat at which the reduction of different metallic oxides can be effected. The oxides of lead, bismuth, antimony, nickel, cobalt, copper, and iron, require a strong red heat in the furnace, whilst the oxides of manganese, chromium, tin, and zinc, do not lose their oxygen until heated to whiteness.

On a large scale, the reduction of oxides is generally effected by mixing charcoal, together with the oxide to be reduced, in a refractory clay crucible, the charcoal furnishing the carbon necessary to the proper performance of the work. Some use a crucible thickly lined with charcoal, putting in the oxide on the top of the charcoal. It is necessary, however, when using the crucible and charcoal, to use a flux, say a little borax in powder, stewed on the mixture to accelerate the reduction of the oxide. The borax is generally the first to fuse, and, as the metal is eliminated, seems to purify and cleanse it, as it gathers into a button at the bottom of the crucible. It is all the better if you give the crucible a few sharp taps when you take it off the fire.

Copper Plates or Rods may be covered with a superficial coating of brass by exposing them to the *fumes* given off by melted zinc at a light temperature. The coated plates or rods can then be rolled into thin sheets; or drawn into wire.

Solution of Copper on Zinc.—Dissolve 8 oz. (troy) cyanide of potassium, and 3 oz. cyanide of copper or zinc, in 1 gallon of rainwater. To be used at about 160° F., with a compound battery of 3 to 12 cells.

Brass Solution.—Dissolve 1 lb. (troy) cyanide of potassium, 2 ozs. cyanide of copper, and 1 oz. cyanide of zinc, in 1 gal. of rain-water; then add 2 oz. of muriate ammonia. To be used at 160° F., for smooth work, with a compound battery of from 3 to 12 cells.

Brassing Iron.—Iron ornaments are covered with copper or brass, by properly preparing the surface so as to remove all organic matter which would prevent adhesion and then plunging them into melted brass. A thin coating is thus spread over the iron, and it admits of being polished or burnished.

To Enamel Cast Iron and Hollow Ware.—Calcined flints 6 parts; Cornish stone or *composition* two parts, litharge 9 parts, borax 6 parts, argillaceous earth 1 part, nitre 1 part, calx of tin 6 parts, purified potash 1 part. 2. Calcined flints 8 parts, red lead 8 parts, borax 6 parts, calx of tin 5 parts, nitre 1 part. 3. Potter's composition 12 parts, borax 8 parts, white lead 10 parts, nitre 2 parts, white marble calcined 1 part, purified potash 2 parts, calx of tin 5 parts. 4. Calcined flints 4 parts, potter's composition 1 part, nitre 2 parts, borax 8 parts, white marble calcined 1 part, argillaceous earth ½ part, calx of tin 2 parts. Whichever of the above compositions is taken must be finely powdered, mixed and fused. The vitreous mass is to be ground when cold, sifted, and levigated with water; it is then made into a pap with water, or gum-water. This pap is smeared or brushed over the interior of the vessel, dried, and fused with a proper heat in a muffle. Clean the vessels perfectly before applying.

Enameled Cast Iron.—Clean and brighten the iron before applying. The enamel consists of two coats—the body and the glaze. The body is made by fusing 100 lbs. ground flints, 75 of borax, and grinding 40 lbs. of this frit with 5 lbs. of potter's clay, in water, till it is brought to the consistence of a pap. A coat of this being applied and dried, but not hard, the glaze powder is sifted over it. This consists of 100 lbs. Cornish stone in fine powder, 117 of borax, 35 of soda ash, 35 of nitre, 35 of sifted slaked lime, 13 of white sand, and 50 of pounded white glass. These are all fused together; the frit obtained is pulverized. Of this powder, 45 lbs. are mixed with 1 lb. of soda ash, in hot water, and the mixture dried in a stove is the glaze-powder. After sifting this over the body-coat, the cast iron article is put into a stove, kept at a temperature of about 212°, to dry it hard, after which it is set in a muffle-kiln, to fuse it into a glaze. The inside of pipes is enamelled (after being cleaned) by pouring the above body-composition through them while the pipe is being turned around to insure an equal coating; after the body has become set, the glaze pap is poured in in like manner. The pipe is finally fired in the kiln.

To Enamel Copper and other Vessels.—Flint glass 6 parts, borax 3 parts, red lead 1 part, oxide of tin 1 part. Mix all to-

gether, frit, grind into powder, make into a thin paste with water, apply with a brush to the surface of the vessels (after scaling by heat and cleaning them), repeat with a second or even a third coat, afterwards dry, and lastly fuse on by heat of an enamelled kiln.

Emery Wheels for Polishing.—Coarse emery powder is mixed with about half its weight of pulverized Stourbridge loam, and a little water or other liquid to make a thick paste; this is pressed into a metallic mould by means of a screw-press, and, after being thoroughly dried, is baked or burned in a muffle at a temperature above a red, and below a white heat. This forms an artificial emery-stone, which cuts very greedily, with very little wear to itself. Unequalled for grinding and polishing glass, metals, enamels, stones, &c.

Refining Gold and Silver.—The art of assaying gold and silver is founded upon the feeble affinity which these have for oxygen in comparison with copper, tin, and other cheap metals, and on the tendency which the latter metals have to oxidize rapidly in contact with lead at a high temperature, and sink with it into any porous, earthy vessel in a thin, glassy, vitrified mass. The precious metal having previously been accurately weighed and prepared, the first process is CUPELLATION. The *muffle*, with cupel properly arranged on the "*muffle plate*," is placed in the furnace, and the charcoal added, and lighted at the top by means of a few ignited pieces thrown on last. After the cupels have been exposed to a strong white heat for about half an hour, and have become white hot, the lead is put into them by means of tongs. As soon as this becomes bright red and "*circulating*," as it is called, the specimen for assay, wrapped in a small piece of paper or lead-foil, is added; the fire is now kept up strongly until the metal enters the lead and "*circulates*" well, when the heat, slightly diminished, is so regulated that the assay appears convex and more glowing than the cupel itself, whilst the "*undulations*" circulate in all directions, and the middle of the metal appears smooth, with a margin of litharge, which is freely absorbed by the cupel. When the metal becomes bright and shining, or, in the technical language, begins to "*lighten*," and prismatic hues suddenly flash across the globules, and undulate and cross each other, followed by the metal becoming very brilliant and clear, and at length bright and solid (called *the brightening*), the separation is ended, and the process complete. The cupels are then drawn to the mouth of the "muffle," and allowed to cool slowly. When quite cold, the resulting "*button*," if of SILVER, is removed by the "pliers" or "tongs" from the cupels, and after being flattened on a small *anvil of polished steel*, with a polished steel hammer, to detach adhering oxide of lead, and cleaned with a small, hard brush, is very *accurately weighed*. The weight is that of *pure silver*, and the difference between the weight before cupellation and that of the pure metal represents the proportion of alloy in the sample examined. In the case of GOLD, the metal has next to undergo the operations of QUARTATION. The cupelled sample is fused with three times

its weight of pure silver (called the "*witness*,") and in this state may be easily removed by PARTING. The alloy, after quartation, is hammered or rolled out into a thin strip or leaf, curled into a spiral form, and boiled for a quarter of an hour with about 2½ to 3 ounces of nitric acid (specific gravity, 1.3); and the fluid being poured off, it is again boiled in a similar manner, with 1½ to 2 ounces more nitric acid (sp. gr., 1.2); after which the gold is carefully collected, washed in pure water, and dried. When the operation of parting is skilfully conducted, the acid not too strong, the metal preserves its spiral form; otherwise it falls into flakes or powder. The second boiling is termed the "*reprise*." The loss of weight by parting corresponds to the quantity of SILVER originally in the specimen.

For Alloys containing Platinum, which usually consist of copper, silver, platinum, and gold, the method of assaying is as follows: The alloy is cupelled in the usual way, the loss of weight expresses the amount of *copper*, and the "button," made into a riband and treated with sulphuric acid, indicates by the portion dissolved that also of the *silver* present. By submitting the residuum to quartation, the *platinum* becomes soluble in nitric acid. The loss after digestion in this menstruum expresses the weight of that metal, and the weight of the portion now remaining is that of pure gold. Gold containing PALLADIUM may be assayed in the same manner.

Annealing.—This consists in putting the pure gold into a small, porous crucible, or cupel, and heating it to redness in the muffle. WEIGHING must be done with the utmost accuracy. The weight in grains troy, doubled or quadrupled as the case may be, gives the number of *carats fine* of the alloy examined, without calculation.

According to the OLD FRENCH METHOD of assaying gold, the following quantities were taken: For the *assay pound*, 12 gr.; fine silver, 30 grs.; lead, 108 grs. These having been cupelled together, the perfect button is rolled into a leaf (1¼ by 5 inches), twisted on a quill, and submitted to parting with 2½ oz. and 1½. oz. of nitric acid, sp. gr., 1.16 (20° Baume). The remainder of the process is similar to that above described.

The usual weight of silver taken for the *assay pound*, when the fineness is reckoned in 1000ths, is 20 grs., every real grain of which represents 50-1000ths of fineness, and so on of smaller divisions.

Enamelling on Gold and Copper.—The basis of all enamels is a highly transparent and fusible glass, called FRIT, FLUX, or PASTE, which readily receives a color on the addition of the metallic oxides. PREPARATION.—Red lead, 16 parts; calcined borax, 3 parts; pounded flint glass, 12 parts; flints, 4 parts. Fuse in a Hessian crucible for 12 hours, then pour it out into water, and reduce it to powder in a biscuit-ware mortar. The following directions will serve to show how the coloring preparations are made: BLACK enamels are made with peroxide of manganese, or protoxide of iron, to which more depth of color is given with a little cobalt. VIOLET enamel of a very fine hue is made from peroxyde

of manganese in small quantity with saline or alkaline fluxes. RED enamel is made from protoxide of copper. Boil a solution of equal parts of sugar and acetate of copper in four parts of water. The sugar takes possession of a portion of the cupreous oxide, and reduces it to the protoxide; when it may be precipitated in the form of a granular powder of a brilliant red. After about two hours of moderate boiling, the liquid is set aside to settle, decanted off the precipitate, which is washed and dried. By this pure oxide any tint may be obtained from red to orange by adding a greater or smaller quantity of peroxide of iron. The oxide and purple of cassius are likewise employed to colored enamel. This composition resists a strong fire very well. GREEN enamel can be produced by a mixture of yellow and blue, but is generally obtained direct from the oxide of copper, or better still with the oxide of chrome, which last will resist a strong heat. YELLOW.—Take one part of white oxide of antimony, with from one to three parts of white lead, one of alum, and one of sal ammoniac. Each of these substances is to be pulverized, then all are to be exactly mixed, and exposed to a heat adequate to decompose the sal ammoniac. This operation is judged to be finished when the yellow color is well brought out. BLUE.—This color is obtained from the oxide of cobalt, or some of its combinations, and it produces it with such intensity that only a very little can be used lest the shade should pass into black. A WHITE enamel may be prepared with a *calcine* formed of 2 parts of tin and 1 of lead, calcined together: of this combined oxide, 1 part is melted with two parts of fine crystal and a very little manganese, all previously ground together. When the fusion is complete, the vitreous matter is to be poured into clear water, and the frit is then dried and melted anew. Repeat the pouring into water three or four times, to insure a perfect combination. Screen the crucible from smoke and flame. The smallest portions of oxide of iron or copper admitted into this enamel will destroy its value.

The artist prepares his enamel colors by pounding them in an agate mortar, with an agate pestle, and grinding them on an agate slab, with oil of lavender rendered viscid by exposure to the sun, in a shallow vessel, loosely covered with gauze or glass. He should have alongside of him a stove, in which a moderate fire is kept up, for drying his work whenever the fignres are finished. It is then passed through the muffle.

Silver Plating.—File the parts which are to receive the plate very smooth; then apply over the surface the muriate of zinc, which is made by dissolving zinc in muriatic acid; now hold this part over a dish containing hot soft solder, and with a swab apply the solder to the part to which it will adhere; brush off all superfluous solder, so as to leave the surface smooth; you will now take No. 2 fair silver plate, of the right size to cover the prepared surface, and lay the plate upon it, and rub down smooth with a cloth moistened with oil; then, with a turned soldering iron, pass slowly over all the surface of the plate, which melts the solder underneath it, causing the plate to adhere as firmly as the solder does to the iron; then polish the surface, and finish with buckskin.

Electro Gold Plating.—Take a $2.50 piece of gold, and put it into a mixture of 1 oz. nitric, and 4 oz. muriatic acid (glass vessels only are to be used in this work;) when it is all cut, dissolve ½ oz. of sulphate of potash in 1 pint of pure rain water, and mix with the gold solution, stirring well; then let it stand, and the gold will be thrown down; then pour off the acid fluid, and wash the gold in two or three waters, or until no acid is tasted by touching the tongue to the gold. Now dissolve 1 oz. of cyanuret of potassium in 1 pint of pure rain water, to which add the gold, and it is ready for use. Clean the article to be plated from all grease and dirt, with whiting and a good brush; if there are cracks, it may be necessary to put the article in a solution of caustic potash; at all events clean it perfectly; then suspend it in the cyanuret of gold solution with a small strip of zinc, cut about the width of a common knitting needle, hooking the top over a stick which will reach across the top of the vessel holding the solution. If the zinc is too large, the deposit will be made so fast it will scale off. The slower the plating goes on the better, and this is arranged by the size of the zinc used. When not in use keep it well corked and out of the way of children, for it is very poisonous.

Electro Silver Plating is done every way the same as gold (using coin,) except that rock-salt is used instead of the cyanuret of potassium, to hold the silver in solution for use, and when it is of the proper strength of salt, it has a thick curdy appearance, or you can add salt until the silver will deposit on the article to be plated, which is all that is required. This method entails no trouble with using a battery, and is the successful result of a long series of experiments in electro-plating.

Elkington's Patent Gilding.—Fine gold, 5 oz. (troy;) nitro-muriatic acid, 52 oz. (avoirdupois;) dissolve by heat, and continue the heat until red or yellow vapors cease to be evolved; decant the clear liquor into a suitable vessel; add *distilled* water, 4 gallons; pure bi-carbonate of potassa, 20 lbs.; and boil for 2 hours. N. B. The nitro-muriatic acid is made with *pure* nitric acid (sp. gr. 1.45,) 21 oz.; *pure* muriatic acid (sp. gr. 1.15,) 17 oz.; and *distilled* water, 14 oz.

The articles, after being perfectly cleaned from scale or grease, and receiving a proper *face*, are to be suspended on wires, dipped into the liquid *boiling hot*, and moved about therein, when, in from a few seconds to a minute, depending on the newness and strength of the liquid, the requisite coating of gold will be deposited on them. By a little practice the time to withdraw the articles is readily known; the duration of the immersion required to produce any given effect gradually increases as the liquid weakens by use. When properly gilded, the articles are withdrawn from the solution of gold, washed in clean water and dried; after which they undergo the usual operation of coloring, &c.

A "*dead gold*" *appearance* is produced by the application to the articles of a *weak* solution of *nitrate of mercury* previously to the immersion in the gilding liquor, or the *deadening* may be given by applying a solution of the nitrate to the *newly gilded* surface, and then expelling the mercury by heat.

Cold Silvering on Metals.—Mix 1 part of chloride of silver with 3 parts of pearlash, 1½ parts common salt, and 1 part whiting; and well rub the mixture on the surface of brass or copper, (previously well cleaned,) by means of a piece of soft leather, or a cork moistened with water, and dipped in the powder. When properly silvered, the metal should be well washed in hot water, slightly alkalized, then wiped dry.

To Heighten the Color of Yellow Gold.—Saltpetre, 6 oz.; green copperas, 2 oz.; white vitriol and alum, of each, 1 oz. If wanted redder, a small quantity of blue vitriol must be added.

For Green Gold.—Saltpetre, 1 oz. 10 dwts.; sal ammoniac, 1 oz. 4 dwts.; Roman vitriol, 1 oz. 4 dwts.; verdigris, 18 dwts.

For Red Gold.—To 4 oz. melted yellow wax, add, in fine powder, 1½ oz. of red ochre; 1½ oz. verdigris, calcined till it yields no fumes; and ½ oz. of calcined borax. Mix them well together. Dissolve either of above mixtures in water, as the color is wanted, and use as required.

Coloring of Gilding.—Defective colored gilding may also be improved by the help of the following mixture: Nitrate of potash, 3 oz.; alum, 1½ oz.; sulphate of zinc, 1½ oz.; common salt, 1½ oz. These ingredients are to be put into a small quantity of water to form a sort of paste, which is put upon the articles to be colored; they are then placed upon an iron plate over a clear fire, so that they will attain nearly to a black heat, when they are suddenly plunged into cold water; this gives them a beautiful high color. Different hues may be had by a variation in the mixture.

Gold is taken from the surface of silver by spreading over it a paste made of powdered sal-ammoniac, with aqua fortis, and heating it till the matter smokes, and it is nearly dry; when the gold may be separated by rubbing it with a scratch brush.

Moulds and Dies.—Copper, zinc, and silver in equal proportions, melt together under a coat of powdered charcoal, and mould into the form you desire. Bring them to nearly a white heat, and lay on the thing you would take the impression of, press with sufficient force, and you will get a perfect and beautiful impression.

Polishing Powder for Gold and Silver.—Rock alum (burnt and finely powdered,) 5 parts; levigated chalk, 1 part. Mix; apply with a dry brush.

Silver Plating Fluid.—Dissolve 1 ounce of nitrate of silver in crystal, in 12 ounces of soft water; then dissolve in the water 2 oz. cyanuret of potash; shake the whole together, and let it stand till

it becomes clear. Have ready some half-ounce vials, and fill half full of Paris white, or fine whiting; and then fill up the bottles with the liquor, and it is ready for use. The whiting does not increase the coating power; it only helps to clean the articles, and save the silver fluid, by half filling the bottles.

To Temper Gravers and Drills.—When the graver or drill is too hard, which may be known by the frequent breaking of the point, temper as follows: Heat a poker red hot, and hold the graver to it within an inch of the point, waving it to and fro till the steel changes to a light straw color; then put the point into oil to cool, or hold the graver close to the flame of a candle till it be of the same color, and cool in tallow; but be careful either way not to hold it too long, for then it will be too soft, in which case the point will be blue, and must be broken off, and whetted and tempered anew. For jewellers' drills, no better tempering liquid can be got than the first-named liquid under the blacksmiths' department, which see.

Jeweler's Armenian Cement.—Isinglass soaked in water and dissolved in spirit, 2 oz. (thick); dissolve in this 10 grains of very pale gum ammonia (in tears) by rubbing them together; then add 6 large tears of gum mastic, dissolved in the least possible quantity of rectified spirit. When carefully made, this cement resists moisture and dries colorless. Keep in a closely stopped vial.

Jeweler's Turkish Cement.—Put into a bottle 2 oz. of isinglass and 1 oz. of the best gum arabic; cover them with proof spirits, cork loosely, and place the bottle in a vessel of water, and boil it till a thorough solution is effected; then strain for use; best cement known.

Reviver of Old Jewelry.—Dissolve sal-ammoniac in urine, and put the jewelry in it for a short time; then take it out, and rub with chamois leather, and it will appear equal to new.

To Recover Gold From Gilt Metal.—Take a solution of borax water, apply to the gilt surface, and sprinkle over it some finely powdered sulphur; make the article red hot, and quench it in water; then scrape off the gold, and recover it by means of lead.

To Separate Gold and Silver from Lace, &c.—Cut in pieces the gold or silver lace, tie it tightly, and boil it in soap lye till the size appears diminished; take the cloth out of the liquid, and, after repeated rinsings in cold water, beat it with a mallet to draw out all the alkali. Open the linen, and the pure metal will be found in all its beauty.

Door Plates—TO MAKE.—Cut your glass the right size, and make it perfectly clean with alcohol or soap; then cut a strip of tinfoil sufficiently long and wide for the name, and with a piece of

ivory or other burnisher rub it lengthwise to make it smooth; now wet the glass with the tongue (as saliva is the best sticking substance,) or if the glass is very large, use a weak solution of gum arabic, or the white of an egg in half a pint of water, and lay on the foil, rubbing it down to the glass with a bit of cloth, then also with the burnisher; the more it is burnished the better will it look; now mark the width on the foil which is to be the height of the letter, and put on a straight edge, and hold it firmly to the foil, and with a sharp knife cut the foil, and take off the superfluous edges; then either lay out the letters on the back of the foil (so they shall read correctly on the front) by your own judgment or by means of pattern letters, which can be purchased for that purpose; cut with the knife, carefully holding down the pattern or straight edge, whichever you use; then rub down the edge of all the letters with the back of the knife, or edge of the burnisher, which prevents the black paint or japan which you next put over the back of the plate from getting under the foil; having put a line above and one below the name, or a border around the whole plate or not as you bargain for the job. The Japan is made by dissolving asphaltum in just enough turpentine to cut it (see "Asphaltum Varnish;") apply with a brush, as other paint, over the back of the letters, and over the glass forming a back ground. This is used on the iron plate of the frame, also putting it on when the plate is a little hot; and, as soon as it cools, it is dry. A little lamp-black may be rubbed into it if you desire it any blacker than it is without it.

Etching on Glass.—Druggist bottles, bar-tumblers, signs, and glassware of every description, can be lettered in a beautiful style of art, by simply giving the article to be engraved, or etched, a thin coat of the engraver's varnish (see next receipt), and the application of fluoric acid. Before doing so, the glass must be thoroughly cleaned and heated, so that it can hardly be held. The varnish is then to be applied lightly over, and made smooth by dabbing it with a small ball of silk, filled with cotton. When dry and even, the lines may be traced on it by a sharp steel, cutting clear through the varnish to the glass The varnish must be removed clean from each letter, otherwise it will be an imperfect job. When all is ready, pour on or apply the fluoric acid with a feather, filling each letter. Let it remain until it etches to the required depth, then wash off with water, and remove the varnish.

Etching Varnish.—Take of virgin wax and asphaltum each 2 oz.; of black pitch and Burgundy pitch, each ½ oz.; melt the wax and pitch in a new earthenware glazed pot, and add to them, by degrees, the asphaltum, finely powdered. Let the whole boil, simmering gradually, till such time as that, taking a drop upon a plate, it will break when it is cold, on bending it double two or three times betwixt the fingers. The varnish, being then boiled enough, must be taken off the fire, and, after it cools a little, must be poured into warm water that it may work the more easily with the hands, so as to be formed into balls, which must be kneaded, and put into a piece of taffety for use.

Fluoric Acid, to Make for Etching Purposes.—You can make your own fluoric (sometimes called hydro-fluoric) acid, by getting the fluor or Derbyshire spar, pulverizing it, and putting all of it into sulphuric acid which the acid will cut or dissolve. Inasmuch as fluoric acid is destructive to glass, it cannot be kept in common bottles, but must be kept in lead or gutta percha bottles.

Glass-Grinding for Signs, Shades, Etc.—After you have etched a name or other design upon uncolored glass, and wish to have it show off to a better advantage by permitting the light to pass only through the letters, you can do so by taking a piece of flat brass sufficiently large not to dip into the letters, but pass over them when gliding upon the surface of the glass; then, with flour of emery, and keeping it wet, you can grind the whole surface, very quickly, to look like the ground glass globes often seen upon lamps, except the letter, which is eaten below the general surface.

Gold and Silver Ink.—The metal leaf is ground with honey until of a fine powder; it is then washed to remove the honey, and the powder is mixed with gum water for use.

Gold Lustre for Stoneware, China, Etc.—Gold, 6 parts; aquaregia, 36 parts. Dissolve, then add tin, 1 part; next add balsam of sulphur, 3 parts; oil of turpentine, 1 part. Mix gradually into a mortar, and rub it until the mixture becomes hard; then add oil of turpentine, 4 parts. It is then to be applied to a ground prepared for the purpose.

Gilding China and Glass.—Powdered gold is mixed with borax and gum water, and the solution applied with a camel-hair pencil. Heat is then applied by a stove until the borax fuses, when the gold is fixed and afterwards burnished.

Glass Staining.—The following colors, after having been prepared, and rubbed upon a plate of ground-glass, with the spirit of turpentine or lavender, thickened in the air, are applied with a hair-pencil. Before using them, however, it is necessary to try them on small pieces of glass, and expose them to the fire, to ascertain if the desired tone of color is produced. The artist must be guided by these proof-pieces in using his colors. The glass proper for receiving these pigments should be colorless, uniform and difficult of fusion. A design must be drawn on paper, and placed beneath the plate of glass. The upper side of the glass, being sponged over with gum-water, affords, when dry, a surface proper for receiving the colors without the risk of their running irregularly, as they would otherwise do on the slippery glass. The artist draws on the plate (usually in black), with a fine pencil, all the traces which mark the great outlines or shades of the figures. Afterwards, when it is dry, the vitrifying colors are laid on by means of larger hair-pencils; their selection being regulated by the burnt specimen-tints above mentioned. The following are all fast colors, which do not run, except the yellow, which must, therefore, be laid on the opposite side of the glass. The preparations being all laid on, the glass is ready for being fired in a muffle, in order to fix and bring out the proper colors. The muffle must be made of very refractory fire-

clay, flat at its bottom, and only five or six inches high, with a strong, arched roof, and close on all sides, to exclude smoke and flame. On the bottom, a smooth bed of sifted lime, freed from water, about half an inch thick, must be prepared for receiving the glass. Sometimes, several plates of glass are laid over each other, with a layer of lime-powder between each. The fire is now lighted, and very gradually raised, lest the glass should be broken; then keep it at a full heat for three or four hours, more or less, according to the indications of the trial slips; the yellow coloring being principally watched, it furnishing the best criterion of the state of the others. When all is right, let the fire die out, so as to anneal the glass.

Stained-Glass Pigments.—No. 1. *Flesh color.*—Red lead, 1 oz.; red enamel (Venetian glass enamel, from alum and copperas calcined together): grind them to a fine powder, and work this up with alcohol upon a hard stone. When slightly baked, this produces a fine flesh color.

No. 2. BLACK COLOR.—Take 14½ oz. of smithy scales of iron; mix them with 2 oz. of white glass; antimony 1 oz.; manganese, ½ oz.: pound and grind these ingredients together, with strong vinegar.

No. 3. BROWN COLOR.—White glass or enamel, 1 oz.; good manganese, ½ oz.: grind together.

No. 4. RED, ROSE AND BROWN COLORS are made from peroxide of iron, prepared by nitric acid. The flux consists of borax, sand and minium, in small quantities.

RED COLOR may likewise be obtained from 1 oz. of red chalk, pounded, mixed with 2 oz. of white, hard enamel, and a little peroxide of copper.

A RED may also be composed of rust of iron, glass of antimony, yellow glass of lead, such as is used by potters (or litharge,) each in equal quantities; to which a little sulphuret of silver is added. This composition, well ground, produces a very fine red color on glass.

No. 5. GREEN.—2 oz. of brass, calcined into an oxide; 2 oz.; of minium, and 8 oz. of white sand: reduce them to a fine powder, which is to be enclosed in a well-luted crucible, and heated strongly in an air-furnace for an hour. When the mixture is cold, grind it in a brass mortar. Green may, however, be advantageously produced, by a yellow on one side, and a blue on the other. Oxide of chrome has been also employed to stain glass green.

No. 6. A FINE YELLOW STAIN.—Take fine silver, laminated thin, dissolve in nitric acid, dilute with abundance of water, and precipitate with solution of sea-salt; mix this chloride of silver in a dry powder, with three times its weight of pipe-clay, well burnt and pounded. The back of the glass pane is to be painted with this powder; for; when painted on the face, it is apt to run into the other colors.

A PALE YELLOW can be made by mixing sulphuret of silver with glass of antimony and yellow ochre, previously calcined to a red-brown tint. Work all these powders together, and paint on the back of the glass. Or silver *laminæ*, melted with sulphur, and glass of antimony, thrown into cold water, and afterwards ground to powder, afford a yellow.

A PALE YELLOW may be made with the powder resulting from brass, sulphur and glass of antimony, calcined together in a crucible till they cease to smoke, and then mixed with a little burnt ochre.

THE FINE YELLOW of M. Meraud is prepared from chloride of silver, oxide of zinc, and rust of iron. This mixture, simply ground, is applied on the glass.

ORANGE COLOR.—Take 1 part of silver-powder, as precipitated from the nitrate of that metal, by plates of copper, and washed; mix with 1 part of red ochre, and 1 of yellow, by careful trituration; grind into a thin pap, with oil of turpentine or lavender; apply this with a brush, and burn in.

Silvering Looking-Glasses with Pure Silver.—Prepare a mixture of 3 grs. of ammonia, 60 grs. nitrate of silver, 90 minims of spirits of wine, 90 minims of water; when the nitrate of silver is dissolved, filter the liquid, and add a small quantity of sugar (15 grs.,) dissolved in 1½ oz. of water and 1½ oz. spirits of wine. Put the glass into this mixture, having one side covered with varnish, gum, or some substance to prevent the silver being attached to it. Let it remain for a few days, and you have a most elegant looking-glass; yet it is far more costly than the quicksilver.

Another Method.—A sheet of tin-foil corresponding to the size of the plate of glass is evenly spread on a perfectly smooth and solid marble table, and every wrinkle on its surface is carefully rubbed down with a brush; a portion of mercury is then poured on, and rubbed over the foil with a clean piece of soft woolen stuff, after which, two rules are applied to the edges, and mercury poured on to the depth of a crown piece; when any oxide on the surface is carefully removed, and the sheet of glass, perfectly clean and dry, is slid along over the surface of the liquid metal, so that no air, dirt, or oxide can possibly either remain or get between them. When the glass has arrived at its proper position, gentle pressure is applied, and the table sloped a little to carry off the waste mercury; after which it is covered with flannel, and loaded with heavy weights; in twenty-four hours, it is removed to another table, and further slanted, and this position is progressively increased during a month till it becomes perpendicular.

Porcelain Colors.—The following are some of the colors used in the celebrated porcelain manufactory of Sevres, and the proportions in which they are compounded. Though intended for porcelain painting, nearly all are applicable to painting on glass. Flux No. 1 minium or red lead, 3 parts; white sand, washed, 1 part. This mixture is melted, by which it is converted into a

greenish-colored glass. Flux No. 2. GRAY FLUX.—Of No. 1, 8 parts; fused borax in powder, 1 part; this mixture is melted. Flux No. 3. FOR CARMINES AND GREENS.—Melt together fused borax, 5 parts; calcined flint, 3 parts; pure minium, 1 part. No. 1. INDIGO BLUE. —Oxide of cobalt, 1 part; flux No. 3, 2 parts. DEEP AZURE BLUE. —Oxide of cobalt, 1 part; oxide of zinc, 2 parts; flux No. 3, 5 parts; No. 2. EMERALD GREEN.—Oxide of copper, 1 part; antimonic acid, 10 parts; flux No. 1, 30 parts; pulverize together, and melt. No. 3. GRASS GREEN.—Green oxide of chromium, 1 part; flux No. 3, 3 parts; triturate and melt. No. 4. YELLOW.—Antimonic acid, 1 part; subsulphate of the peroxyde of iron, 8 parts; oxide of zinc, 4 parts; flux No. 1, 36 parts; rub together, and melt; if this color is too deep, the salt of iron is diminished. No. 5. FIXED YELLOW FOR TOUCHES.—No. 4, 1 part; white enamel of commerce, 2 parts; melt and pour out; if not sufficiently fixed, a little sand may be added. No. 6. DEEP NANKIN YELLOW.—Subsulphate of iron, 1 part; oxide of zinc, 2 parts; flux No. 2, 8 parts; triturate without melting. No. 7. DEEP RED.—Subsulphate of iron, calcined in a muffle until it becomes of a beautiful capucine red, 1 part; flux No. 2, 3 parts; mix without melting. No. 8. LIVER BROWN.—Oxide of iron made of red brown, and mixed with 3 times its weight of flux. No. 2; a tenth of sienna earth is added to it, if it is not deep enough. No. 9. WHITE.—The white enamel of commerce, in cakes. No. 10. DEEP BLACK.—Oxide of cobalt, 2 parts; copper, 2 parts; oxide of manganese, 1 part; flux No. 1, 6 parts; fused borax, ½ part; melt, and add oxide of manganese, 1 part; oxide of copper, 2 parts; triturate without melting.

THE APPLICATION.—Follow the general directions given in another part of this work, in relation to staining glass.

Glass and Porcelain Gilding.—Dissolve in boiled linseed oil an equal weight either of copal or amber; add as much oil of turpentine as will enable you to apply the compound or size thus formed, as thin as possible, to the parts of the glass intended to be gilt. The glass is to be placed in a stove till it will almost burn the fingers when handled; at this temperature the size becomes adhesive, and a piece of gold-leaf, applied in the usual way, will immediately stick. Sweep off the superfluous portions of the leaf, and when quite cold it may be burnished; taking care to interpose a piece of India paper between the gold and the burnisher. See another process in a previous part of this work.

Soluble Glass.—1. Silica, 1 part; carbonate of soda, 2 parts; fuse together. 2. Carbonate of soda, (dry,) 54 parts; dry carbonate of potassa, 70 parts; silica, 192 parts; soluble in boiling water, yielding a fine transparent, semi-elastic varnish. 3. Carbonate of potassa, (dry,) 10 parts; powdered quartz (or sand, free from iron or alumina,) 15 parts; charcoal, 1 part; all fused together. Soluble in 5 or 6 times its weight of *boiling* water. The filtered solution evaportaed to dryness yields a transparent glass, permanent in the air.

To Drill and Ornament Glass.—Glass can be easily drilled by a steel drill, hardened but not drawn, and driven at a high velocity. Holes of any size, from the 16th of an inch upwards, can be drilled, by using spirits of turpentine as a dip; and, easier still, by using camphor with the turpentine. Do not press the glass very hard against the drill. If you require to ornament glass by turning in a lathe, use a good mill file and the turpentine and camphor drip, and you will find it an easy matter to produce any shape you choose.

Gilding Glass Signs, &c.—Cut a piece of thin paper to the size of your glass, draw out your design correctly in black lead-pencil on the paper, then prick through the outline of the letters with a fine needle, tie up a little dry white lead in a piece of rag; this is a pounce-bag. Place your design upon the glass, right side up, dust it with the pounce-bag; and, after taking the paper off, the design will appear in white dots upon the glass; these will guide you in laying on the gold on the opposite side, which must be *well cleaned*, preparatory to laying on the gold. PREPARING THE SIZE.—Boil perfectly clean water in an enamelled saucepan, and while boiling, add 2 or 3 shreds of best selected isinglass, after a few minutes strain it through a clean linen rag; when cool it is ready for use. CLEAN THE GLASS PERFECTLY.—When this is done, use a flat camel's-hair brush for laying on the size; and let it drain off when you put the gold on. When the gold is laid on and perfectly dry, take a ball of the finest cotton wool and gently rub or polish the gold; you can then lay on another coat of gold if desirable; it is now ready for writing. In doing this, mix a little of the best vegetable black japan; thin with turpentine to a proper working consistency; apply this when thoroughly dry; wash off the superfluous gold, and shade as in sign-writing.

Gilder's Gold Size.—Drying or boiled linseed oil, thickened with yellow ochre, or calcined red ochre, and carefully reduced to the utmost smoothness by grinding. It is thinned with oil of turpentine.

To Gild Letters on Wood, &c.—When your sign is prepared as smooth as possible, go over it with a sizing made by the white of an egg dissolved in about four times its weight of cold wafer; adding a small quantity of fuller's earth; this is to prevent the gold sticking to any part but the letters. When dry, set out the letters and commence writing, laying on the size as thinly as possible, with a sable pencil. Let it stand until you can barely feel a slight stickiness, then go to work with your gold leaf knife and cushion, and gild the letters. Take a leaf up on the point of your knife, after giving it a slight puff into the back part of your cushion, and spread it on the front part of the cushion as straight as possible, giving it another slight puff with your mouth to flatten it out. Now cut it into the proper size, cutting with the heel of your knife forwards. Now rub the tip lightly on your hair; take up the gold

on the point, and place it neatly on the letters; when they are all covered get some very fine cotton wool, and gently rub the gold until it is smooth and bright. Then wash the sign with clean water to take off the egg size.

Compound Colors.—LIGHT GRAY is made by mixing white lead with lamp-black, using more or less of each material, as you wish to obtain a lighter or darker shade. BUFF is made from yellow ochre and white lead. SILVER OR PEARL GRAY.—Mix white lead, indigo, and a very slight portion of black, regulating the quantities you wish to obtain. FLAXEN GRAY is obtained by a mixture of white lead and Prussian blue, with a small quantity of lake. BRICK COLOR.—Yellow ochre and red lead, with a little white. OAK WOOD COLOR.—Three-fourths white lead and one-fourth part umber and yellow ochre, proportions of the last two ingredients being determined by the desired tints. WALNUT-TREE COLOR.—Two-thirds white lead, and one-third red ochre, yellow ochre, and umber mixed according to the shade sought. If veining is required, use different shades of the same mixture, and for the deepest places, black. JONQUIL.—Yellow, pink and white lead. This color is only proper for distemper. LEMON YELLOW.—Realgar and orpiment. The same color can be obtained by mixing yellow-pink with Naples yellow; but it is then only fit for distemper. ORANGE COLOR.—Red lead and yellow ochre. VIOLET COLOR.—Vermilion, or red lead, mixed with black or blue, and a small portion of white. Vermilion is far preferable to red lead in mixing this color. PURPLE.—Dark-red mixed with violet color. CARNATION.—Lake and white. GOLD COLOR.—Massicot, or Naples yellow, with a small quantity of realgar, and a very little Spanish white. OLIVE COLOR may be obtained by black and a little blue, mixed with yellow. Yellow-pink, with a little verdigris and lamp-black; also ochre and a small quantity of white will produce an olive color. For distemper, indigo and yellow-pink mixed with white lead or Spanish white must be used. If veined it must be done with umber. LEAD COLOR.—Indigo and white. CHESTNUT COLOR. — Red ochre and black, for a dark chestnut. To make it lighter, employ a mixture of yellow ochre. LIGHT TIMBER COLOR.—Spruce ochre, white, and a little umber. FLESH COLOR.—Lake, white lead, and a little vermilion. LIGHT WILLOW GREEN.—White mixed with verdigris. GRASS GREEN.—Yellow-pink mixed with verdigris. STONE COLOR.—White, with a little spruce ochre. DARK LEAD COLOR.—Black and white, with a little indigo. FAWN COLOR.—White lead, stone ochre, with a little vermilion. CHOCOLATE COLOR.—Lamp-black and Spanish brown. On account of the fatness of lamp-black, mix some litharge and red lead. PORTLAND STONE COLOR.—Umber, yellow ochre, and white lead.

Dyes for Veneers.—A FINE BLACK.—Put 6 lbs. of logwood chips into your copper, with as many veneers as it will hold without pressing too tight; fill it with water, let it boil slowly for about 3 hours, then add ½ lb. of *powdered verdigris*, ½ lb. copperas, bruised gall-nuts, 4 oz.; fill the copper up with vinegar, as the water evaporates; let it boil gently two hours each day till the wood is dyed through. A FINE BLUE.—Put oil of vitrol, 1 lb., and 4 oz. of

the best powdered indigo, in a glass bottle. Set it in a glazed earthen pan, as it will ferment. Now put your veneers into a copper or stone trough; fill it rather more than one-third with water, and add as much of the vitriol and indigo (stirring it about) as will make fine blue, testing it with a piece of white paper or wood. Let the veneers remain till the dye has struck through. Keep the solution of indigo a few weeks before using it; this improves the color. FINE YELLOW.—Reduce 4 lbs. of the root of barberry to dust by sawing, which put in a copper or brass trough; add turmeric, 4 oz.; water, 4 gals.; then put in as many white holly veneers as the liquor will cover. Boil them together for three hours, often turning them. When cool, add aquafortis, 2 oz., and the dye will strike through much sooner. BRIGHT GREEN.—Proceed as in the previous receipt to produce a yellow; but, instead of aquafortis, add as much of the vitriolated indigo (see above, under blue dye) as will produce the desired color. BRIGHT RED.—Brazil dust, 2 lbs.; add water, 4 gals. Put in as many veneers as the liquid will cover; boil them for 3 hours, then add alum, 2 oz.; aquafortis, 2 oz.; and keep it luke-warm until it has struck through. PURPLE.—To 2 lbs. of chip logwood and ½ lb. Brazil dust, add 4 gals. of water; and after putting in your veneers, boil for 3 hours; then add pearlash, 6 oz., and alum, 2 oz.; let them boil for 2 or 3 hours every day till the color has struck through. ORANGE.—Take the veneers out of the above yellow dye, and while still wet and saturated, transfer them to the bright red dye till the color penetrates throughout.

Gilders' Pickle.—Alum and common salt, each 1 oz.; nitre, 2 oz.; dissolved in water, ½ pt. Used to impart a rich yellow color to gold surfaces. It is best used largely diluted with water.

To Silver Ivory.—Pound a small piece of nitrate of silver in a mortar, add soft water to it, mix them well together, and keep in a phial for use. When you wish to silver any article, immerse it in this solution, let it remain till it turns of a deep yellow; then place it in clear water, and expose it to the rays of the sun. If you wish to depicture a figure, name, or cipher, on your ivory, dip a camel's hair pencil in the solution, and draw the subject on the ivory. After it has turned a deep yellow, wash it well with water, and place it in the sunshine, occasionally wetting it with pure water. In a short time it will turn of a deep black color, which, if well rubbed, will change to a brilliant silver.

To Improve the Color of Stains..—Nitric acid, 1 oz.; muriatic, ½ teaspoonful; grain tin, ¼ oz.; rain water, 2 oz. Mix it at least 2 days before using, and keep your bottle well corked.

Strong Glue for Inlaying or Veneering.—Select the best light brown glue, free from clouds and streaks. Dissolve this in water, and to every pint add ½ a gill of the best vinegar and ½ oz. of isinglass.

Compound Iron Paint.—Finely pulverized iron filings, 1 part; brick dust, 1 part; and ashes, 1 part. Pour over them glue-water or size, set the whole near the fire, and, when warm, stir them well together. With this paint cover all the wood-work which may be in danger; when dry, give a second coat, and the wood will be rendered incombustible.

Best Wash for Barns and Houses.—Water lime, 1 peck; freshly slacked lime, 1 peck; yellow ochre in powder, 4 lbs.; burnt umber, 4, lbs. To be dissolved in hot water, and applied with a brush.

Durable Outside Paint.—Take 2 parts (in bulk) of water lime, ground fine; 1 part (in bulk) of white lead, in oil. Mix them thoroughly, by adding *best* boiled linseed oil, enough to prepare it to pass through a paint mill; after which, temper with oil till it can be applied with a common paint brush. Make any color to suit It will last 3 times as long as lead paint. IT IS SUPERIOR.

Farmers' Paint.—Farmers will find the following profitable for house or fence paint: skim milk, 2 quarts; fresh slacked lime, 8 oz.; linseed oil, 6 oz., white Burgundy pitch, 2 oz.; Spanish white, three pounds. The lime is to be slacked in water, exposed to the air, and then mixed with about one-fourth of the milk; the oil in which the pitch is dissolved to be added, a little at a time; then the rest of the milk, and afterwards the Spanish white. This is sufficient for 27 yards, 2 coats. This is for white paint. If desirable, any other color may be produced; thus, if a cream color is desired, in place of part of the Spanish white, use the ochre alone.

Painting in Milk.—Skimmed milk, ½ gallon; newly slacked lime, 6 oz.; and 4 oz. of poppy, linseed, or nut oil; and 5 lbs. Spanish white. Put the lime into an earthen vessel or clean bucket; and, having poured on it a sufficient quantity of milk to make it about the thickness of cream, add the oil in small quantities, a little at a time, stirring the mixture well. Then put in the rest of the milk, afterward the Spanish white finely powdered, or any other desired color. For out-door work add 2 oz. each more of oil and slacked lime, and 2 oz. of Burgundy pitch dissolved in the oil by a gentle heat.

Premium Paint, Without Oil or Lead.—Slack stone lime with boiling water in a tub or barrel to keep in the steam; then pass 6 quarts through a fine sieve. Now to this quantity add 1 quart of coarse salt, and 1 gallon of water; boil the mixture, and skim it clear. To every 5 gallons of this skimmed mixture, add 1 lb. alum; ½ lb. copperas; and by slow degrees ¾ lb. potash, and 4 quarts sifted ashes or fine sand; add any coloring desired. A more durable paint was never made.

Green Paint for Garden Stands, Blinds, Etc.—Take mineral

green, and white lead ground in turpentine; mix up the quantity you wish with a small quantity of turpentine varnish. This serves for the first coat. For the second, put as much varnish in your mixture as will produce a good gloss. If you desire a brighter green, add a little Prussian blue, which will improve the color.

Milk Paint for Barns.—ANY COLOR.—Mix water lime with skim-milk, to a proper consistence to apply with a brush, and it is ready to use. It will adhere well to wood, whether smooth or rough, to brick, mortar, or stone, where oil has not been used (in which case it cleaves to some extent,) and forms a very hard substance, as durable as the best oil paint. It is too cheap to estimate, and any one can put it on who can use a brush. Any color may be given to it, by using colors of the tinge desired. If a red is preferred, mix Venetian-red with milk, not using any lime. It looks well for fifteen years.

Paint.—TO MAKE WITHOUT LEAD OR OIL.—Whiting, 5 lbs.; skimmed milk, 2 qts.; fresh slacked lime, 2 oz. Put the lime into a stone-ware vessel, pour upon it a sufficient quantity of the milk to make a mixture resembling cream; the balance of the milk is then to be added; and lastly, the whiting is to be crumbled upon the surface of the fluid, in which it gradually sinks. At this period, it must be well stirred in, or ground as you would other paint, and it is fit for use.

Substitute for White Lead.——Hard cake stearine, 100 lbs.; bleached resin, 90 lbs.; fine potato starch, 25 lbs. Melt and mix well. Then add mucilage, 20 lbs.; stir well, till nearly cool; then put away for use.

Paints, Different Sorts.—BLUE.—Blue-black, 25 lbs.; whiting, 100 lbs.; road dust, sifted, 200 lbs.; lime-water, 12 gallons. Factitious linseed oil to grind.

WHITE PAINT.—Whiting, 500 lbs.; white-lead, 400 lbs.; lime-water, 20 gallons Factitious linseed-oil to grind.

BLACK PAINT.—Ivory or lamp-black, 100 lbs.; road-dust, sifted, 200 lbs.; lime-water, 18 gallons. Oil to grind.

BROWN PAINT.—Venetian red, or Spanish brown, 1 cwt.; road-dust, 3 cwt.; common soot, 28 lbs.; lime-water, 15 lbs. Factitious linseed oil to grind.

PARIS GREEN.—Take unslacked lime of the best quality, slack it with hot water; then take the finest part of the powder, and add alum-water as strong as it can be made, sufficient to form a thick paste; then color it with bi-chromate of potash and sulphate of copper until the color suits your fancy, and dry it for use. N. B.—The sulphate of copper gives a blue tinge; the bi-chromate of potash, a yellow. Observe this, and you will get it right.

Beautiful Green Paint for Walls.—Take 4 lbs. Roman vitriol, and pour on it a tea-kettle full of boiling water. When dissolved, add 2 lbs. pearlash, and stir the mixture well with a stick until the effervescence ceases; then add ¼ lb. pulverized yellow

arsenic, and stir the whole together. Lay it on with a paint-brush; and, if the wall has not been painted before, two, or even three coats will be requisite. If a pea green is required, put in less; if an apple green, more of the yellow arsenic. This paint does not cost the quarter of oil-paint, and looks better.

Blue Color for Ceilings, &c.—Boil slowly for 3 hours 1 lb. blue vitriol and ½ lb. of the best whiting in about 3 qts. water; stir it frequently while boiling, and also on taking it off the fire. When it has stood till quite cold, pour off the blue liquid, then mix the cake of color with good size, and use it with a plasterer's brush in the same manner as whitewash, either for walls or ceilings.

To Harden Whitewash.—With ½ a pail of common whitewash add ½ pint of flour. Pour on boiling water in a sufficient quantity to thicken it. Then add 6 gals. of the lime and water, and stir well.

Whitewash that will not rub off.—Mix up half a pailful of lime and water, ready to put on the wall; then take ¼ pt. of flour, mix it up with water, then pour on it the boiling water, a sufficient quantity to thicken it; then pour it while hot into the whitewash, stir all well together, and it is ready for use.

Whitewash.—The best method of making a whitewash for outside exposure is to slack half a bushel of lime in a barrel, add one pound of common salt, half a pound of the sulphate of zinc, and a gallon of sweet milk.

Substitute for Plaster of Paris.—Best whitening, 2 lbs.; glue, 1 lb.; linseed oil, 1 lb. Heat all together, and stir thoroughly. Let the compound cool, and then lay it on a stone covered with powdered whitening, and heat it well till it becomes of a tough and firm consistence; then put it by for use, covering with wet cloths to keep it fresh. When wanted for use, it must be cut in pieces adapted to the size of the mould, into which it is forced by a screw press. The ornament may be fixed to the wall, picture-frame, &c., with glue or white lead. It becomes in time as hard as stone itself.

Glue.—Powdered chalk added to common glue strengthens it. A glue which will resist the action of water is made by boiling 1 lb. of glue in 2 qts of skimmed milk.

Cheap Waterproof Glue.—Melt common glue with the smallest possible quantity of water; add, by degrees, linseed oil, rendered drying by boiling it with litharge. While the oil is added, the ingredients must be well stirred, to incorporate them thoroughly.

Fire and Waterproof Glue.—Mix a handful of quick-lime with 4 oz. of linseed oil; thoroughly lixiviate the mixture; boil it to a good thickness, and spread it on tin plates in the shade; it will become very hard, but can be dissolved over a fire, like common glue, and is then fit for use.

Prepared Liquid Glue.—Take of best white glue, 16 oz.;

white-lead, dry, 4 oz.; rain-water, 2 pts.; alcohol, 4 oz. With constant stirring, dissolve the glue and lead in the water, by means of a water-bath. Add the alcohol, and continue the heat for a few minutes. Lastly, pour into bottles, while it is still hot.

Prussian Blue.—Take nitric acid, any quantity, and as much iron shavings from the lathe as the acid will dissolve; heat the iron as hot as it can be handled with the hand; then add to it the acid in small quantities as long as the acid will dissolve it; then slowly add double the quantity of soft water that there was of acid, and put in iron again as long as the acid will dissolve it. 2. Take prussiate of potash, dissolve it in hot water to make a strong solution, and make sufficient of it with the first to give the depth of tint desired, and the blue is made. Or,—

Another Method.—A very passable Prussian blue is made by taking sulphate of iron (copperas) and prussiate of potash, equal parts of each; and dissolving each separately in water, then mixing the two waters.

Chrome Yellow.—1. Take sugar of lead and Paris white, of each 5 lbs.; dissolve them in hot water. 2. Take bi-chromate of potash, 6½ oz., and dissolve it in hot water also; each article to be dissolved separately; then mix all together, putting in the bi-chromate last. Let stand twenty-four hours.

Chrome Green.—Take Paris white, 6½ lbs.; sugar of lead, and blue vitriol, of each, 3½ lbs.; alum, 10½ oz.; best soft Prussian blue and chrome yellow, of each, 3⅓ lbs. Mix thoroughly while in fine powder, and add water, 1 gallon, stirring well and let stand three or four hours.

Green, Durable and Cheap.—Take spruce yellow, and color it with a solution of chrome yellow and Prussian blue, until you give it the shade you wish.

Another Method.—Blue vitriol, 5 lbs.; sugar of lead 6¼ lbs.; arsenic, 2½ lbs.; bi-chromate of potash, 1½ oz.; mix them thoroughly in fine powder, and add water 3 parts, mixing well again, and let stand three or four hours.

Pea Brown.—1. Take sulphate of copper any quantity, and dissolve it in hot water. 2. Take prussiate of potash, dissolve it in hot water to make a strong solution; mix of the two solutions, as in the blue, and the color is made.

Rose Pink.—Brazil wood, 1 lb., and boil it for two hours, having 1 gallon of water at the end; then strain it, and boil alum, 1 lb., in the same water until dissolved; when sufficiently cool to admit the hand, add muriate of tin, ¾ oz. Now have Paris white, 12½ lbs.; moisten up to a salvy consistence, and when the first is cool stir them thoroughly together. Let stand twenty-four hours.

Patent Yellow.—Common salt, 100 lbs. and litharge, 400 lbs., are ground together with water, and kept for some time in a gentle heat, water being added to supply the loss by evaporation; the carbonate of soda is then washed out with more water, and the white residuum heated till it acquires a fine yellow color.

Naples Yellow.—No. 1. Metallic antimony, 12 lbs.; red lead, 8 lbs.; oxide of zinc, 4 lbs. Mix; calcine, triturate well together, and fuse in a crucible: the fused mass must be ground and elutriated to a fine powder.

Cheap Yellow Paint.—Whiting, 3 cwt.; ochre, 2 cwt.; ground white lead, 25 lbs. Factitious linseed oil to grind.

Stone Color Paint.—Road dust, 2 cwt.; ground white lead, ½ cwt.; whiting, 1 cwt.; ground umber, 14 lbs.; lime water, 6 gals. Factitious linseed oil to grind.

Glazier's Putty.—Whiting, 70 lbs.; boiled oil, 30 lbs.; water, 2 gals. Mix; if too thin, add more whiting; if too thick, add more oil.

Fish Oil Paints.—Dissolve white vitriol and litharge, of each 14 lbs., in vinegar, 32 gals.; add whale, seal, or cod oil, 1 tun, and boil to dryness, continually stirring during the ebullition. The next day, decant the clear portion; add linseed oil, 12 gals., oil of turpentine, 3 gals., mix well together. The sediment left is well agitated with half its quantity of lime water, used for some inferior paints under the name of "*prepared residue oil.*" This oil is used for various common purposes, as a substitute for linseed oil, of which the following paints are examples:—

1. PALE GREEN.—Lime water, 6 gals; whiting and road dust, of each, 1 cwt.; blue-black, 30 lbs.; yellow ochre, 28 lbs.; wet blue (previously ground in *prepared residue oil,*) 20 lbs.; grind well together. For use, thin with equal parts of *prepared residue oil* and linseed oil.

2. BRIGHT GREEN.—Yellow ochre and wet blue, of each, 1 cwt.; road dust, 1½ cwt.; blue-black, 10 lbs.; limewater, 6 gals.; prepared fish oil, 4 gals.; prepared residue and linseed oils, of each, 7½ gals.

3. LEAD COLOR.—Whiting, 1 cwt.; blue-black, 7 lbs.; white lead, (ground in oil,) 28 lbs ; road dust, 56 lbs.; lime water, 5 gals.; prepared residue oil, 2½ gals.

4. REDDISH BROWN.—Lime water, 8 gals.; Spanish brown, 1 cwt.; road dust, 2 cwt.; prepared fish, prepared residue and linseed oils, of each, 4 gals.

5. YELLOW.—Substitute ochre for Spanish brown in the last receipt.

6. BLACK.—Substitute lamp or blue-black for Spanish brown in No. 4.

7. STONE COLOR.—Lime water, 4 gals.; whiting, 1 cwt.; white lead (ground in oil), 28 lbs.; road dust, 56 lbs.; prepared fish, linseed, and prepared residue oils, of each, 3 gals.

8. CHOCOLATE.—Nos. 4 and 6 mixed together so as to form a chocolate color.

REMARKS.—All the above paints require a little "driers." They are well fitted, by their cheapness, hardness, and durability, for common out-door work.

Porcelain Finish, very Hard and White for Parlors.—To prepare the wood for finish, if it be pine, give one or two coats of the "Varnish—Transparent for Wood," which prevents the pitch

from oozing out, causing the finish to turn yellow; next, give the room at least four coats of pure zinc, which may be ground in only sufficient oil to enable it to grind properly; then mix to a proper consistence with turpentine or naphtha. Give each coat time to dry. When it is dry and hard, sandpaper it to a perfectly smooth surface, when it is ready to receive the finish, which consists of two coats of French zinc ground in, and thinned with Demar varnish, until it works properly under the brush.

Japan Drier, BEST QUALITY.—Take linseed oil, 1 gallon; put into it gum shellac, ¾ lb.; litharge and burned Turkey umber, each ½ lb.; red lead, ½ lb.; sugar of lead, 6 oz. Boil in the oil till all are dissolved, which will require about four hours; remove from the fire, and stir in spirits turpentine 1 gallon, and it is done.

Another.—Linseed oil, 5 gallons; add red lead and litharge, each 3½ lbs.; raw umber, 1¼ lbs.; sugar of lead and sulphate of zinc, each ½ lb.; pulverize all the articles together, and boil in the oil till dissolved; when a little cool, thin with turpentine, 5 gallons.

Drying Oil Equal to Patent Driers at One Quarter their Price.—Linseed oil, 2 gallons; red lead and umber, each, 4 oz.; sulphate of zin·, 2 oz.; sugar of lead, 2 oz. Boil until it will scorch a feather, when it is ready for use.

Prepared Oil for Carriages, &c.—To 1 gallon linseed oil add 2 lbs. gum shellac; litharge, ½ lb.; red lead, ¼ lb.; umber, 1 oz. Boil slowly as usual until the gums are dissolved; grind your paints in this (any color,) and reduce with turpentine. Yellow ochre is used in floor painting.

Drying Oils. 1.—Nut or linseed oil, 1 gal.; litharge, 12 oz; sugar of lead and white vitriol, of each 1 oz.; simmer and skim until a pellicle forms; cool, and, when settled, decant the clear. 2. Oil, 1 gal.; litharge, 12 to 16 oz.; as last. 3. Old nut or linseed oil, 1 pint; litharge, 3 oz. Mix; agitate occasionally for 10 days; then decant the clear. 4. Nut oil and water, of each 2 lbs.; white vitriol, 2 oz.; boil to dryness. 5. Mix oil with powdered snow or ice, and keep it for 2 months without thawing.

To reduce Oil Paint with Water.—Take 8 lbs. of pure unslacked lime, add 12 qts. water, stir it and let it settle, turn it off gently and bottle it, keep it corked till used. This will mix with oil, and in proportion of half will render paint more durable.

Oil Paint.—TO REDUCE WITH WATER.—Gum shellac, 1 lb.; sal-soda, ½ lb.; water, 3 parts; boil all together in a kettle, stirring till dissolved. If it does not all dissolve, add a little more sal-soda; when cool, bottle for use; mix up 2 quarts of oil paint as usual, any color desired, using no turpentine; put 1 pint of the gum shellac mixture with the oil paint when it becomes thick; it can then be reduced with water to a proper thickness to lay on with a brush.

Another Method.—Soft water, 1 gallon; dissolve it in pearlash, 3 oz.; bring to a boil, and slowly add shellac, 1 lb.; when cold it is ready to be added to oil paint in equal proportions.

How to build Gravel Houses.—This is the best building material in the world. It is four times cheaper than wood, six times

cheaper than stone, and superior to either. Proportions for mixing: To eight barrows of slacked lime, well deluged with water, add 15 barrows of sand; mix these to a creamy consistency, then add 60 barrows of coarse gravel, which must be worked well and completely; you can then throw stones into this mixture, of any shape or size, up to ten inches in diameter. Form moulds for the walls of the house by fixing boards horizontally against upright standards which must be immovably braced so that they will not yield to the immense pressure outwards as the material settles; set the standards in pairs around the building where the walls are to stand, from six to eight feet apart, and so wide that the inner space shall form the thickness of the wall, Into the moulds thus formed throw in the concrete material as fast as you choose, and the more promiscuously the better. In a short time the gravel will get as hard as the solid rock.

Flexible Paint for Canvas.—Yellow soap, 2½ lbs., boiling water, 1½ gals., dissolve; grind the solution while hot with *good oil paint*, 1¼ cwt. Use for canvas.

Painter's Cream.—Pale nut oil, 6 oz., mastic, 1 oz., dissolve; add of sugar of lead, ¼ oz., previously ground in the least possible quantity of oil, then add of water *q. s.*, gradually, until it acquires the consistency of cream, working it well all the time. Used to cover the unfinished work of painters. It will wash off with water.

Mastic Cement for Covering the Fronts of Houses.—Fifty parts, by measure, of clean dry sand, fifty of limestone (not burned) reduced to grains like sand, or marble dust, and ten parts of red lead, mixed with as much boiled linseed oil as will make it slightly moist. The bricks to receive it should be covered with three coats of boiled oil, laid on with a brush, and suffered to dry before the mastic is put on. It is laid on with a trowel like plaster, but it is not so moist. It becomes hard as stone in a few months. Care must be exercised not to use too much oil.

Cement for Outside of Brick Walls.—Cement for the outside of brick walls, to imitate stone, is made of clean sand, 90 parts; litharge, 5 parts; plaster of Paris, 5 parts; moistened with boiled linseed oil. The bricks should receive two or three coats of oil before the cement is applied.

Cement for Tile Roofs.—Equal parts of whiting and dry sand, and 25 per cent. of litharge, made into the consistency of putty with linseed oil. It is not liable to crack when cold, nor melt, like coal-tar and asphalt, with the heat of the sun.

Excellent Cheap Roofing.— SHINGLES SUPERSEDED.—Have your roof stiff. rafters made of stuff 1½ by 8 inches, well supported and 6 feet apart, with ribs 1 inch by 2 inches, set edgeways, well nailed to the rafters, about 18 inches apart. The boards may be thin, but must be well seasoned, and nailed close together; this done, lay down and cover the roof with thin, soft, spongy straw paper used in making paper-boxes, which comes in rolls, and comes

very low. Lay in course up and down the roof, and lap over, nailing down with common No. 6 tacks, with leather under the heads like carpet-tacks. Then spread on several coatings of the following composition, previously boiled, stirred, and mixed together: good clean tar, 8 gals.; Roman cement, 2 gals. (or in its place very fine, clean sand may be used;) resin, 5 lbs.; tallow, 3 lbs.; apply hot; and let a hand follow, and shift on sharp grit sand, pressing it into the tar composition. If wished fire-proof, go over the above with the following preparation: Slake stone lime under cover with hot water till it falls into a fine powder; sift and mix 6 qts. of this with 1 qt. salt, add 2 gals. water, boil and skim. To 5 gals. of this add 1 lb. alum, and 1½ lbs. of copperas, and slowly, while boiling, 1½ lbs. potash, and 4 qts. of clean, sharp sand, and any coloring desired. Apply a thick coat with a brush, and you may have a roof which no fire can injure from the outside.

Water Lime at Fifty Cents per Barrel.—Fine, clean sand, 100 lbs.; quick lime in powder, 28 lbs.; bone-ashes, 14 lbs.; for use, beat up with water, and use as quick as possible.

To Render Wood Indestructible.—ROBBINS'S PROCESS.—This seems to be a process of inestimable value, and destined to produce very important results. The apparatus used consists of a retort or still, which can be made of any size or form, in which resin, coal tar, or other oleaginous substances, together with water, are placed in order to subject them to the action of heat. Fire being applied beneath the retort containing the coal tar, &c., oleaginous vapor commences to rise, and pass out through a connecting pipe into a large iron tank or chamber (which can also be built of any size), containing the timber, &c., to be operated upon. The heat acts at once on the wood, causing the sap to flow from every pore, which, rising in the form of steam, condenses on the body of the chamber, and discharges through an escape pipe in the lower part. In this process a temperature of 212° to 250° Fahr. is sufficient to remove the surface moisture from the wood; but after this the temperature should be raised to 300° or more, in order to completely saturate and permeate the body of the wood with the antiseptic vapors and heavier products of the distillation. The hot vapor coagulates the albumen of the wood, and opens the pores, so that a large portion of the oily product or creosote is admitted; the contraction resulting from the cooling process hermetically seals them, and decay seems to be almost impossible. There is a man hole in the retort, used to change or clean out the contents; and the wood chamber is furnished with doors made perfectly tight. The whole operation is completed in less than one hour, rendering the wood proof against rot, parasites, and the attacks of the *Teredo navilis* or naval worm.

Cement for Seams In Roofs.—Take equal quantities of white lead and white sand, and as much oil as will make it into the consistence of putty. It will in a few weeks become as hard as stone.

Roman Cement.—Drift sand, 84 parts; unslacked lime, 12 lbs.; and 4 lbs. of the poorest cheese grated; mix well; add hot (not boiling) water to reduce to a proper consistence for plastering. Work well and quick with a thin, smooth coat.

Smalt.— Roast cobalt ore to drive off the arsenic; make the residuum into a paste with oil of vitriol, and heat it to redness for an hour; powder, dissolve in water, and precipitate the oxide of iron by carbonate of potash, gradually added until a rose-colored powder begins to fall; then decant the clear, and precipitate by a solution of silicate of potash prepared by fusing together for 5 hours a mixture of 10 parts of potash, 15 parts of finely ground flints, and 1 part charcoal. The precipitate, when dry, may be fused and powdered very fine.

Fictitious Linseed Oil.—Fish or vegetable oil, 100 gallons; acetate of lead, 7 lbs.; litharge, 7 lbs.; dissolved in vinegar, 2 gallons. Well mixed with heat, then add boiled oil, 7 gallons; turpentine, 1 gallon. Again well mix.

Varnishes.—COMMON OIL VARNISH.—Resin, 4 lbs.; beeswax, ½ lb.; boiled oil, 1 gallon; mix with heat; then add spirits turpentine, 2 quarts.

MASTIC VARNISH.—Mastic, 1 lb.; white wax, 1 oz.; spirits turpentine, 1 gallon; reduce the gums small; then digest it with heat in a close vessel till dissolved.

TURPENTINE VARNISH.—Resin, 1 lb.; boiled oil, 1 lb.; melt; then add turpentine, 2 lbs. Mix well.

PALE VARNISH.—Pale African copal, 1 part; fuse. Then add hot pale oil, 2 parts. Boil the mixture till it is stringy; then cool a little, and add spirits turpentine, 3 parts.

LACQUER VARNISH.—A good lacquer is made by coloring lacquer varnish with turmeric and annotto. Add as much of these two coloring substances to the varnish as will give it the proper color; then squeeze the varnish through a cotton cloth, when it forms lacquer.

Deep Gold-Colored Lacquer.—Seed lac, three ounces; turmeric, one ounce; dragon's blood, one-fourth ounce; alcohol, one pint; digest for a week, frequently shaking; decant, and filter.

Lacquers are used upon polished metals and wood to impart the appearance of gold. If yellow is required, use turmeric, aloes, saffron, or gamboge; for red, use annotto, or dragon's blood, to color. Turmeric, gamboge, and dragon's blood generally afford a sufficient range of colors.

Gold Varnish.—Digest shellac, sixteen parts gum sandarach mastic, of each three parts; crocus, one part; gum gamboge, two parts; all bruised, with alcohol, one hundred and forty-four parts. Or, digest seedlac, sandarach, mastic, of each eight parts; gamboge, two parts; dragon's blood, one part; white turpentine, six parts; turmeric, four parts; bruised with alcohol one hundred and twenty parts.

Gold Lacquer.—Put into a clean four-gallon tin 1 pound of ground turmeric, 1½ ozs. of gamboge, 3½ lbs. of powdered gum sandarach, ¾ of a lb. of shellac, and two gallons of spirits of wine. When shaken, dissolved, and strained, add 1 pint of turpentine varnish, well mixed.

Polish for Turner's Work.—Dissolve sandarach, 1 oz., in spirits of wine, ½ pt.; next shave beeswax, 1 oz.; and dissolve it in a sufficient quantity of spirits turpentine to make it into a paste; add the former mixture by degrees to it, then with a woolen cloth apply it to the work while it is in motion in the lathe, and with a soft linen rag polish it. It will appear as if highly varnished.

Varnish for Tools.—Take tallow, 2 oz.; resin, 1 oz., and melt together. Strain while hot to get rid of specks which are in the resin; apply a slight coat on your tools with a brush, and it will keep off rust for any length of time.

Gold Varnish.—Turmeric, 1 dram; gamboge, 1 dram; turpentine, 2 pints; shellac, 5 oz.; sandarach, 5 oz.; dragon's blood, 8 drams; thin mastic varnish, 8 oz.; digest with occasional agitation for 14 days; then set it aside to fine, and pour off the clear.

Book-Binder's Varnish.—Shellac, eight parts; gum benzoin, 3 parts; gum mastic, two parts; bruise, and digest in alcohol, 48 parts; oil of lavender, ½ part. Or, digest shellac, 4 parts; gum mastic, 2 parts; gum dammer and white turpentine, of each 1 part; with alcohol (95 per cent.), 28 parts.

Beautiful Pale Amber Varnish.—Amber, pale and transparent, 6 lbs.; fuse; add hot clarified linseed oil, 2 gals.; boil till it strings strongly, cool a little, and add oil of turpentine, 4 gals. This soon becomes very hard, and is the most durable of oil varnishes. When wanted to dry quicker, drying oil may be substituted for linseed, or "driers" may be added during the cooling.

Black Coach-Varnish.—Amber, 1 lb.; fuse; add hot *drying* oil, ½ pt.; powdered black resin and Naples asphaltum, of each 3 oz. When properly incorporated and considerably cooled, add oil of turpentine, 1 pt.

Body Varnish.—Finest African copal, 8 lbs.; fuse carefully; add clarified oil, 2 gals.; boil gently for 4½ hours, or until quite stringy; cool a little, and thin with oil of turpentine, 3½ gals. *Dries slowly.*

Carriage Varnish.—Sandarach, 19 oz.; pale shellac, 9½ oz.; very pale transparent resin, 12½ oz.; turpentine, 18 oz.; 85 per cent. alcohol, 5 pts.; dissolve. Used for the internal parts of carriages, &c. Dries in ten minutes.

Cabinet-Maker's Varnish.—Very pale shellac, 5 lbs.; mastic, 7 oz.; alcohol, 90 per cent, 5 or 6 pts.; dissolve in the cold with frequent stirring. Used for French polishing, &c.

Japanner's Copal Varnish.—Pale African copal, 7 lbs; fuse;

add clarified linseed oil, ½ gal.; boil five minutes, remove it into the open air; add boiling oil of turpentine, 3 gals.; mix well, strain it into the cistern, and cover it up immediately. Used to varnish furniture, and by japanners, coachmakers, &c.

Copal Varnish.—Pale, hard copal, 8 lbs.; add hot and pale drying oil, 2 gals.; boil till it strings strongly, cool a little, and thin with hot rectified oil of turpentine, 3 gals.; and strain immediately into the store can. Very fine.

Gold Varnish of Watin, for Gilded Articles.—Gumlac in grains, gamboge, dragon's blood, and annotto, of each 12½ oz.; saffron, 3⅓ oz. Each resin must be dissolved separately in 5 pts. of 90 per cent. alcohol, and two separate tinctures must be made with the dragon's blood and annotto in a like quantity of spirit; and a proper proportion of each mixed together to produce the required shade.

Varnish for Plaster Casts.—White soap and white wax, each ½ oz.; water, 2 pts.; boil together in a clean vessel for a short time. This varnish is to be applied when cold with a soft brush.

Transparent Varnish for Ploughs, &c.—Best alcohol, 1 gal.; gum sandarach, 2 lbs.; gum mastic, ½ lb.; place all in a tin can which admits of being corked; cork tight, shake it frequently, occasionally placing the can in hot water. When dissolved, it is ready for use.

Fine Black Varnish for Coaches.—Melt in an iron pot, amber, 32 oz,; resin, 6 oz.; asphaltum, 6 oz.; drying linseed oil, 1 pt.; when partly cooled, add oil of turpentine, warmed, 1 pint.

Mordant Varnish.—Dissolve 1 oz. mastic, 1 oz. sandarach, ½ oz. gum gamboge, and ¼ oz. turpentine in 6 oz. spirits turpentine. One of the simplest mordants is that procured by dissolving a little honey in thick glue. It has the effect of greatly heightening the color of the gold, and the leaf sticks extremely well.

Changing Varnish.—To IMITATE GOLD OR SILVER, &c. Put 4 oz. best gum gamboge into 32 oz. spirits of turpentine; 4 oz. dragon's blood into 32 oz. spirits turpentine, and 1 oz. of annotto into 8 oz. spirits turpentine. Make the 3 three mixtures in different vessels. Keep them in a warm place, exposed to the sun as much as possible, for about 2 weeks, when they will be fit for use. Add together such quantities of each liquor as the nature of the color you are desirous of obtaining will point out.

Varnish, Transparent, for Wood.—Best alcohol, 1 gal.; nice gum shell, 2½ lbs. Place the jug or bottle in a situation to keep it just a little warm, and it will dissolve quicker than if hot, or left cold.

Patent Varnish for Wood or Canvas.—Take spirits of turpentine, 1 gal.; asphaltum, 2¼ lbs.; put them into an iron kettle which will fit upon a stove, and dissolve the gum by heat. When dissolved and a little cool, add copal varnish, 1 pt.; and boiled linseed oil, 1 pt.; when cold it is ready for use. Perhaps a little lampblack would make it a more perfect black.

Beautiful Varnish for Violins, &c.—Rectified spirits of wine, ½ gal.; add 6 oz. gum sandarach, 3 oz. gum mastic, and ½ pint turpentine varnish; put the above in a tin can by the stove, frequently shaking till well dissolved; strain, and keep for use. If you find it harder than you wish, thin with more turpentine-varnish.

Crimson Stain for Musical Instruments.—Ground Brazil wood, 1 lb.; water, 3 quarts; cochineal, ½ ounce; boil the Brazil with the water for an hour, strain, add the cochineal, boil gently for half an hour, when it will be fit for use. If you wish a *scarlet tint*, boil an ounce of saffron in a quart of water, and pass over the work before you stain it.

Purple Stain.—Chipped logwood, 1 lb.; water, 3 quarts; pearl-ash, 4 ounces; powdered indigo, 2 ounces. Boil the logwood in the water half an hour, add the pearl-ash and indigo, and when dissolved you will have a beautiful purple.

Green Stain.—Strong vinegar, 3 pints; best verdigris, 4 oz. ground fine; sap green, ½ ounce; mixed together.

Black Stains for Wood.—1. Drop a little sulphuric acid into a small quantity of water; brush over the wood, and hold it to the fire; it will be a fine black, and receive a good polish. 2. For a beautiful black on wood, nothing can exceed the *black Japan* mentioned under Tinsmith's Department. Apply two coats; after which, varnish and polish it. 3. To 1 gallon vinegar, add a quarter of a pound of iron-rust; let it stand for a week; then add a pound of dry lamp-black, and three quarters of a pound of copperas; stir it up for a couple of days. Lay on five or six coats with a sponge, allowing it to dry between each; polish with linseed oil and a soft woolen rag, and it will look like ebony. Incomparable for iron work, ships' guns, shot, &c. 4. Vinegar, ½ gallon; dry lamp-black, ½ lb.; iron-rust sifted, 3 lbs.; mix, and let stand for a week. Lay three coats of this on hot, and then rub with linseed oil, and you will have a fine deep black. 5. Add to the above stain nut-galls, 1 oz.; logwood chips, ½ lb.; copperas, ¼ lb,; lay on three coats; oil well, and you will have a black stain that will stand any kind of weather, and is well adapted for ships' combings, &c. 6. Logwood chips, 1 lb.; Brazil wood, ¼ lb.; boil for 1½ hours in one gallon water. Brush the wood with this decoction while hot; make a decoction of nutgalls, by simmering gently, for three or four days, a quarter of a pound of the galls in 2 quarts water; give the wood three coats, and, while wet, lay on a solution of sulphate of iron (2 oz. to a quart,) and, when dry, oil or varnish. 7. Give three coats with a solution of copper-filings in aquafortis, and repeatedly brush over with the logwood decoction until the greenness of the copper is destroyed. 8. Boil ½ lb. logwood chips in 2 quarts water; add an ounce of pearl-ash, and apply hot with a brush. Then take 2 quarts of the logwood decoction, and ½ oz. of verdigris, and the same of copperas; strain, and throw in ½ lb. of iron-rust. Brush the work well with this, and oil.

Rose-wood Stain, Light Shade.—Equal parts of logwood and red-wood chips; boil well in water sufficient to make a strong stain; apply it to the furniture while hot, 2 or 3 coats, according to the depth of color desired.

Rose Pink Stain and Varnish.—Put 1 oz. of potash in 1 qt. water, with red sanders, 1½ oz.; extract the color from the wood, and strain; then add gum shellac, ½ lb.; dissolve it by a brisk fire. Used upon logwood stain for rosewood imitation.

Blue Stain for Wood.—1. Dissolve copper-filings in aquafortis, brush the wood with it, and then go over the work with a hot solution of pearlash (2 oz. to 1 pint water) till it assumes a perfectly blue color. 2. Boil 1 lb. of indigo, 2 lbs. wood, and 3 oz. alum, in 1 gallon water; brush well over until thoroughly stained.

Imitation of Botany Bay Wood.—Boil ½ lb. of French berries (the unripe berries of the *Rhamnus infectorius*) in 2 quarts water till of a deep yellow, and, while boiling hot, give two or three coats to the work. If a deeper color is desired, give a coat of logwood decoction over the yellow. When nearly dry, form the grain with No. 8 *black stain*, used hot; and, when dry, rust and varnish.

Mahogany Color.—Dark.—1. Boil ½ lb. of madder and 2 oz. logwood chips in a gallon of water, and brush well over while hot, when dry, go over the whole with pearlash solution, 2 drs. to the quart. 2. Put 2 oz. dragon's blood, bruised, into a quart of oil of turpentine; let the bottle stand in a warm place; shake frequently, and, when dissolvod, steep the work in the mixture.

Box Wood Brown Stain.—Hold your work to the fire, that it may receive a gentle warmth; then take aquafortis, and, with a feather, pass it over the work till you find it change to a fine brown (always keeping it near the fire;) you may then varnish or polish it.

Light Brown Red.—Boil ½ lb. madder and ¼ lb. fustic in 1 gal. water; brush over the work, when boiling hot, until properly stained. 2. The surface of the work being quite smooth, brush over with a weak solution of aquafortis, ½ oz. to the pint; then finish with the following: Put 4½ oz. dragon's blood and 1 oz. soda, both well bruised, to 3 pints spirits of wine; let it stand in a warm place, shake frequently, strain, and lay on with a soft brush, repeating until of a proper color. Polish with linseed oil or varnish.

Purple.—Brush the work several times with the logwood decoction used for *No. 6 Black;* and, when dry, give a coat of pearlash solution, 1 drachm to a quart; lay it on evenly.

Red.—1. Boil 1 lb. Brazil wood and 1 oz. pearlash in 1 gallon water; and, while hot, brush over the work until of a proper color. Dissolve 2 oz. alum in 1 quart water, and brush the solution over the work before it dries. 2. Take a gallon of the above stain, add 2 oz. more pearlash; use hot, and brush over with the alum solution. 3. Use a cold solution of archil, and brush over with the pearlash solution used for No. 1 *dark mahogany*.

Ebony Stain.—Infuse gall-nuts in vinegar wherein you have soaked rusty nails; then rub your wood with this; let it dry, polish and burnish.

Bright Yellow Stain.—1. Brush over with the tincture of turmeric. 2. Warm the work, and brush it over with weak aquafortis; varnish or oil as usual. 3. A very small bit of aloes put into the varnish will give a rich yellow color to the wood.

Extra Black Stain for Wood.—Pour 2 qts. boiling water over 1 oz. of powdered extract of logwood, and, when the solution is effected, 1 dr. of yellow chromate of potash is added, and the whole well stirred. It is then ready for use as a wood-stain, or for writing ink. When rubbed on wood, it produces a pure black. Repeat with two, three, or four applications, till a deep black is produced, which acquires the highest beauty when polished or stained.

Imitation of Mahogany.—Let the first coat of painting be white lead; the second, orange; and the last, burnt umber or sienna; imitating the veins according to your taste and practice.

To Imitate Wainscot.—Let the first coat be white; the second, half white and half yellow; and the third, yellow ochre only; shadow with umber or sienna.

To Imitate Satin Wood.—Take white for your first coating, light blue for the second, and dark blue or dark green for the third.

Rosewood Stain, very Bright Shade.—USED COLD.—Take alcohol, 1 gal.; camwood, 2 oz.; set them in a warm place, 24 hours; then add extract of logwood, 3 oz.; aquafortis, 1 oz.; and when dissolved it is ready for use; it makes a very bright ground, like the most beautiful rosewood; one, two, or more coats as you desire, over the whole surface.

Varnish for Frames, Etc.—Lay the frames over with tin or silver foil by means of plaster of Paris, or cement of some kind, that the foil may be perfectly adherent to the wood; then apply your gold lacquer varnish, which is made as follows: ground turmeric, 1 lb.; powdered gamboge, 1½ ounces; powdered sandarach, 3½ lbs.; powdered shellac, ¾ lb.; spirits of wine, 2 gals.; dissolve, and strain; then add turpentine varnish, 1 pt.; and it is ready for use.

Cherry Stain.—Rain water, 3 qts.; annotto, 4 oz.; boil in a copper kettle till the annotto is dissolved, then put in a piece of potash the size of a walnut, keep it on the fire about half an hour longer, and it is ready to bottle for use.

Black Walnut Stain.—New, very cheap, sinks deep, and very good imitation. Dissolve permanganate of potash in water; about 1 oz. to a pailful. Vary to suit the taste. If bought in quantities, this stain should not cost over 50 cents per barrel.

Miscellaneous Stains.—YELLOW is produced by diluted nitric acid RED is produced by a solution of dragon's blood in spirits of wine. BLACK is produced by a strong solution of nitric acid. GREEN is produced by a solution of verdigris in nitric acid. Then dipped in a hot solution of pearlash produces a BLUE stain. PURPLE is produced by a solution of sal-ammoniac in nitric acid.

Finishing with one Coat of Varnish.—VALUABLE PROCESS.—Give the furniture a coat of boiled linseed oil, then immediately sprinkle dry starch upon it, and rub it in well with your hand, or a stiff brush, all over the surface; the starch absorbs the oil, and fills the pores of the wood completely. For black walnut, add a little burned umber to the starch; for cherry, a little Venetian red, &c., according to the color of the wood. Turned work can have it applied while in motion in the lathe. Furniture can afterwards be finished with only one coat of varnish.

Polishes.—CARVER'S POLISH.—White resin, 2 oz.; seed lac, 2 oz.; spirits of wine, 1 pt. Dissolve. It should be laid on warm. Avoid moisture and dampness when used.

2. FRENCH POLISH.—Gum shellac, 1 oz.; gum arabic, ¼ oz.; gum copal, ¼ oz. Powder, and sift through a piece of muslin; put them in a closely corked bottle with 1 pt. spirits of wine, in a very warm situation, shaking every *day* till the gums are dissolved; then strain through muslin, and cork for use.

3. POLISH FOR DARK-COLORED WOODS.—Seed lac, 1 oz.; gum guaiacum, 2 drs.; dragon's blood, 2 drs.; gum mastic, 2 drs.; put in a bottle with 1 pt. spirits of wine, cork close, expose to a moderate heat till the gums are dissolved; strain into a bottle for use, with ¼ gill of linseed oil; shake together.

4. WATER-PROOF POLISH.—Gum benjamin, 2 oz.; gum sandarach, ¼ oz.; gum anima, ¼ oz.; spirits of wine, 1 pt. Mix in a closely stopped bottle, and place either in a sand bath or in hot water till the gums are dissolved, then strain off the mixture, shake it up with a ¼ gill of the best clear poppy oil, and put it by for use.

5. FINISHING POLISH.—Gum shellac, 2 drs.; gum benjamin, 2 drs.; put into ½ pint of best rectified spirits of wine in a bottle closely corked, keep in a warm place, shaking frequently till the gums are dissolved. When cold, shake up with it two teaspoonfuls of the best clear poppy oil.

Polish for Removing Stains, Spots, and Mildew from Furniture.—Take of 98 per cent. alcohol, ½ pt.; pulverized resin and gum shellac, of each, ¼ oz. Let these cut in the alcohol; then add linseed oil, ½ pt.; shake well, and apply with a sponge, brush, or cotton flannel, or an old newspaper, rubbing it well after the application, which gives a nice polish.

Polish for Reviving Old Furniture, Equal to the "Brother Jonathan."—Take alcohol, 1½ oz.; spirits of salts (muriatic acid), ½ oz.; linseed oil, 8 oz.; best vinegar, ½ pt.; and butter of antimony, 1½ oz.; mix, putting in the vinegar last.

Jet or Polish fer Wood or Leather, Black, Red, or Blue.—Alcohol (98 per cent.), 1 pt.; sealing wax, the color desired, 3 sticks; dissolve by heat, and have it warm when applied. A sponge is the best tc apply it with.

Furniture Fillings.—1. Beeswax, spirits of turpentine and linseed oil, equal parts; melt and cool. 2. Beeswax, four oz.; turpentine, 10 oz.; alkanet root, to color; melt and strain. 3. Beeswax, 1 lb.; linseed oil, 5 oz.; alkanet root, one-half ounce; melt, add 5 oz. of turpentine; strain and cool. 4. Beeswax, 4 oz; resin, 1 oz.; oil of turpentine, 2 oz.; Venetian red, to color.

Furniture Polish.—Beeswax, ½ lb.; and a ¼ oz. of alkanet root; melt together in a pipkin until the former is well colored. Then add linseed oil and spirits of turpentine, of each ½ a gill; strain through a piece of coarse muslin.

French Polishes.—1. Shellac, 3 lbs.; wood naphtha, 3 pts.; dissolve. 2. Shellac, 2 lbs.; powdered mastic and sandarach, of each, 1 oz.; copal varnish, ½ pt.; spirits of wine, 1 gal. Digest in the cold till dissolved.

Furniture Fillings.—1. Turpentine, 1 pt.; alkanet root, ½ oz.; digest until sufficiently colored, then add beeswax, scraped small, 4 oz.; put the vessel into hot water, and stir till dissolved. If wanted *pale*, the alkanet root should be omitted. 2 (*White.*) White wax, 1 lb.; liquor of potassa, ½ gal.; boil to a proper consistence. 3. Beeswax, 1 lb.; soap, ¼ lb.; pearlash, 3 oz. (dissolved in water, ½ gal., and strained,) boil as last. 4. Yellow wax, 16 parts; resin, 1 part; alkanet root, 1 part; turpentine, 6 parts; linseed oil, 6 parts. First steep the alkanet in the oil with heat, and, when well colored, pour off the clear on the other ingredients, and again heat till all are dissolved.

Furniture Cream.—Beeswax, 1 lb.; soap, 4 oz.; pearlash, 2 oz.; soft water, 1 gal., boil together until mixed.

Furniture Oils.—1. Acetic acid, 2 dr.; oil of lavender, ½ dr.; rectified spirit, 1 dr.; linseed oil, 4 oz. 2. Linseed oil, 1 pt.; alkanet root, 2 oz.; heat, strain and add lac varnish, 1 oz. 3. Linseed oil, 1 pt.; rectified spirit, 2 oz.; butter of antimony, 4 oz.

Mosaic Gold Powder for Bronzing.—Melt 1 lb. tin in a crucible, and ½ lb. of purified quicksilver to it; when this is cold, it is reduced to powder, and ground, with ½ lb. sal-ammoniac and 7 oz. flour of sulphur, till the whole is thoroughly mixed. They are then calcined in a matrass; and the sublimation of the other ingredients leaves the tin converted into the mosaic gold powder which is found at the bottom of the glass. Remove any black or discolored particles. The sal-ammoniac used must be very white and clear, and the mercury of the utmost purity. When a deeper red is required, grind a very small quantity of red lead with the above materials.

True Gold Powder.—Put some gold-leaf, with a little honey, or thick gum-water made with gum arabic, into an earthen mortar, and pound the mixture till the gold is reduced to very small parti-

cles; then wash out the honey or gum repeatedly with warm water, and the gold in powder will be left behind. When dry, it is fit for use.

Dutch Gold Powder is made from Dutch gold-leaf, which is sold in books at a very low price. Treat in the manner described above for true gold powder. When this inferior powder is used, cover the gilding with a coat of clear varnish, otherwise it will soon lose its bright appearance.

Copper Powder is prepared by dissolving filing or slips of copper with nitrous acid in a receiver. When the acid is saturated, the slips are to be removed; or, if filings be employed, the solution is to be poured off from what remains undissolved. Small bars are then put in, which will precipitate the copper powder from the saturated acid; and, the liquid being poured from the powder, this is to be washed clean of the crystals by repeated waters.

General Directions for Bronzing.—The choice of the above powders is, of course, determined by the degree of brilliancy you wish to obtain. The powder is mixed with strong gum-water or isinglass, and laid on with a brush or pencil; and, when not so dry as to have still a certain clamminess, a piece of soft leather wrapped round the finger is dipped in the powder, and rubbed over the work. When the work has been all covered with the bronze, it must be left to dry, and any loose powder then cleared away by a hair-pencil.

The Bronzing of Plaster Casts is effected by giving them a coat of oil or size varnish, and when this is nearly dry applying with a dabber of cotton or a camel hair-pencil any of the metallic bronze powders; or the powder may be placed in a little bag of muslin, and dusted over the surface, and afterwards finished with a wad of linen. The surface must be afterwards varnished.

Bronzing Iron.—The subject should be heated to a greater degreee than the hand can bear, and German gold, mixed with a small quantity of spirit-of-wine varnish, spread over it with the pencil; should the iron be already polished, you must heat it well, and moisten it with a linen rag dipped in vinegar.

French Burnished Gilding.—*Encollage*, or glue coat. —To a decoction of wormwood and garlic in water, strained through a cloth, a little common salt and some vinegar are added. This is mixed with as much good glue, and the mixture spread in a hot state with a brush of boar's hair. When plaster or marble is gilded, leave out the salt. The first glue-coating is made thinner than the second. 2. *White preparation* consists in covering the above surface with 8, 10, or 12 coats of Spanish white, mixed up with strong size; each well worked on with the brush. 3. *Stop* up the pores with thick whiting and glue, and smooth the surface with dog-skin. 4. *Polish* the surface with pumice-stone and very cold water. 5. *Retouch* the whole in a skilful manner. 6. *Cleanse* with a damp linen rag, and then a soft sponge. 7. *Rub* with a horse's tail (*shave-grass*)

the parts to be yellowed, to make them softer. 8. *Yellow* with *yellow ochre* carefully ground in water, and mixed with transparent colorless size. Use the thinner part of the mixture with a fine brush. 9. Next rub the work with shave-grass to remove any granular appearance. 10. *Gold-water size* consists of Armenian bole, 1 lb.; bloodstone (hematite), 2 oz.; and as much galena, each separately ground in water. Then mix all together with a spoonful of olive oil. This is tempered with a white sheep-skin glue, clear and well strained. Heat and apply three coats with a fine long-haired brush. 11. *Rub* with a clean, dry linen cloth, except the parts to be burnished, which are to receive other two coats of the gold size, tempered with glue. 12. The surface damped with cold water (iced in summer), has then the *gold-leaf* applied to it. Gild the *hollow* ground before the more prominent parts; water being dexterously applied by a soft brush, immediately behind the gold-leaf, before laying it down; removing any excess of water with a dry brush. 13. *Burnish* with bloodstone. 14. Next pass a thin coat of glue, slightly warmed, over the parts that are not to be burnished. 15. Next moisten any broken points with a brush, and apply bits of gold-leaf to them. 16. Apply the *vermeil* coat very lightly over the gold-leaf with a soft brush. It gives lustre and fire to the gold, and is made as follows: annotto, 2 oz.; gamboge, 1 oz.; vermilion, 1 oz.; dragon's blood, ½ oz.; salt of tartar, 2 oz.; saffron, 18 grs.; boil in 2 English pints of water, over a slow fire, till it is reduced to a fourth; then pass the whole through silk or muslin sieve. 17. Next pass over the dead surfaces a second coat of deadening glue, hotter than the first. This finishes the work and gives it strength.

Bronzing or Gilding Wood.—Pipe clay, 2 oz.; Prussian blue, patent yellow, raw umber, lampblack, of each, 1 oz.: grind separately with water on a stone, and as much of them as will make a good color put into a small vessel three-fourths full of size. The wood, being previously cleaned and smoothed, and coated with a mixture of clean size and lampblack, receives a new coating twice successively, with the above compound, having allowed the first to dry. Afterwards the bronze powder is to be laid on with a pencil, and the whole burnished or cleaned anew, observing to repair the parts which may be injured by this operation; next the work must be coated over with a thin layer of Castile soap, which will take the glare off the burnishing; and afterwards be carefully rubbed with a woolen cloth. The superfluous powder may be rubbed off when dry.

Bronze Powder of a PALE GOLD color is produced from an alloy of 13¼ parts of copper, and 2¾ parts zinc, of a CRIMSON METALLIC LUSTRE from copper, of a *paler color*, copper, and a very little zinc; GREEN bronze with a proportion of verdigris, of a fine ORANGE color, by 14½ parts copper and 1¾ zincе; another ORANGE color, 13¾ parts copper and 2¼ zinc. The alloy is laminated into very fine leaves with careful annealing, and these are levigated into impalpable powders, along with a film of fine oil, to prevent oxidizement, and to favor the levigation.

Reviver for Gilt Frames.—White of eggs, 2 oz.; chloride of potash or soda, 1 oz.; mix well, blow off the dust from the frames; then go over them with a soft brush dipped in the mixture, and they will appear equal to new.

Gilding on Wood.—To gild in oil, the wood after being properly smoothed, is covered with a coat of *gold size*, made of drying linseed oil mixed with yellow ochre; when this has become so dry as to adhere to the fingers without soiling them, the gold leaf is laid on with great care and dexterity, and pressed down with cotton wool; places that have been missed are covered with small pieces of gold leaf, and when the whole is dry, the ragged bits are rubbed off with the cotton. This is by far the easiest mode of gilding: any other metallic leaves may be applied in a similar manner. PALE LEAF GOLD has a greenish yellow color, and is an alloy of gold and silver. Dutch gold leaf is only copper leaf colored with the fumes of zinc; being much cheaper than true gold leaf, it is very useful when large quantities of gilding are required in places where it can be defended from the weather, as it changes color if exposed to moisture; and it should be covered with varnish. SILVER LEAF is prepared every way the same as gold leaf; but when applied should be kept well covered with varnish, otherwise it is liable to tarnish; a transparent yellow varnish will give it the appearance of gold. Whenever gold is fixed by means of linseed oil, it will bear washing off, which burnished gold will not.

Best Color for Boot, Shoe, and Harness Edge.—Alcohol, 1 pint; tincture of iron, 1½ oz.; extract logwood, 1 oz.; pulverized nutgalls, 1 oz.; soft water, ½ pint; sweet oil, ½ oz.; put this last into the alcohol before adding the water. Nothing can exceed the beautiful finish imparted to the leather by this preparation. The only objection is the cost.

Cheap Color for the Edge.—Soft water, 1 gallon; extract logwood, 1 oz.; boil till the extract is dissolved; remove from the fire, and add copperas, 2 oz.; bi-chromate of potash and gum arabic, of each, ½ oz.; all to be pulverized.

Superior Edge Blacking.—Soft water, 5 gallons; bring to a boil, and add 8 oz. logwood extract, pulverized; boil 3 minutes, remove from the fire, and stir in 2½ oz. gum arabic, 1 oz. bi-chromate of potash, and 80 grains prussiate of potash.

For a small quantity of this, use water, 2 quarts; extract of logwood, ¾ oz.; gum arabic, 96 grains; bi-chromate of potash, 48 grains; prussiate of potash, 8 grains. Boil the extract in the water 2 minutes; remove from the fire, and stir in the others; and it is ready for use.

For tanners' surface blacking, which is not required to take on a high polish, the gum arabic may be omitted.

Sizing for Boots and Shoes in Treeing Out.—Water, 1 quart; dissolve in it by heat, isingiass, 1 oz.; adding more water

to replace loss by evaporation; when dissolved, add starch, 6 oz.; extract of logwood, beeswax, and tallow, of each 2 oz. Rub the starch up first by pouring on sufficient boiling water for that purpose. It makes boots and shoes soft and pliable, and gives a splendid appearance to old stock on the shelves.

Black Varnish for the Edge.—Take 98 per cent. alcohol, 1 pint; shellac, 3 oz.; resin, 2 oz.; pine turpentine, 1 oz.; lamp-black, ¼ oz.; mix; and when the gums are all cut, it is ready for use. This preparation makes a most splendid appearance when applied to boot, shoe, or harness edge, and is equally applicable to cloth or wood, where a gloss is required after being painted.

Best Harness Varnish Extant.—Alcohol, 1 gallon; white turpentine, 1½ lbs.; gum shellac, 1½ lbs.; Venice turpentine, 1 gill. Let them stand by the stove till the gums are dissolved, then add sweet oil, 1 gill; and color if you wish it with lamp-black, 2 oz. This will not crack like the old varnish.

Another.—Isinglass, or gelatine, and indigo, of each, ¼ oz.; logwood, 4 oz.; soft soap, 2 oz ; glue, 4 oz.; vinegar, 1 pint; mix by heat, and strain.

Brilliant French Varnish for Leather.—Spirit of wine, ¾ pint; vinegar, 5 pints; gum senegal in powder, ½ lb.; loaf sugar, 6 oz.; powdered galls, 2 oz.; green copperas, 4 oz. Dissolve the gum and sugar in the water; strain, and put on a slow fire, but don't boil; now put in the galls, copperas, and the alcohol; stir well for five minutes; set off; and when nearly cool strain through flannel, and bottle for use. It is applied with a pencil brush. Most superior.

Liquid Japan for Leather.—Molasses, 8 lbs.; lamp-black, 1 lb.; sweet oil, 1 lb.; gum arabic, 1 lb.; isinglass, 1 lb. Mix well in 32 lbs. water; apply heat; when cool, add 1 quart alcohol; an ox's gall will improve it.

Waterproof Oil Blacking.—Camphene, 1 pint; add all the India rubber it will dissolve; currier's oil, 1 pint; tallow, 7 lbs.; lamp-black, 2 oz. Mix thoroughly by heat.

Shoemaker's Heel Ball.—Beeswax, 8 oz.; tallow, 1 oz.; melt, and add powdered gum arabic, 1 oz., and lamp-black to color.

Cement for Leather or Rubber Soles and Leather Belting.—Gutta percha, 1 lb.; India rubber, 4 oz.; pitch, 2 oz.; shellac, 1 oz.; oil, 2 oz.; melt and use hot.

Oil Paste Blacking.—Ivory black, 4 lbs.; molasses, 3 lbs.; sweet oil, 1 lb.; oil vitriol, 3 lbs.; mix, and put in tins.

To Dye Leather Blue, Red, or Purple.—For *red*, steep it in alum water, then pass it through a warm decoction of Brazil wood; *blue*, steep in an indigo vat; *purple*, steep the skins in alum water, then put it in a warm decoction of logwood.

Gold Varnish.—Turmeric, 1 drachm; gamboge, 1 drachm; turpentine, 2 pints; shellac, 5 oz.; sandarach, 5 oz.; dragon's blood, 8

drachms; thin mastic varnish, 8 oz.; digest with occasional agitation for fourteen days; then set aside to fine, and pour off the clear.

Grain Black for Harness Leather.—First stain in tallow; then take spirits turpentine, 1 pint; cream of tartar, 1 oz.; soda, 1 oz.; gum shellac, ½ oz.; thick paste reduced thin, 2 quarts. Mix well. This will finish 12 sides.

Stains for Wood and Leather.—RED.—Brazil wood, 11 parts; alum, 4 parts; water, 85 parts. Boil.

BLUE.—Logwood, 7 parts; blue vitriol, 1 part; water, 22 parts. Boil.

BLACK.—Logwood, 9 parts; sulphate of iron, 1 part; water, 25 parts. Boil.

GREEN.—Verdigris, 1 part; vinegar, 3 parts. Dissolve.

YELLOW.—French berries, 7 parts; water, 10 parts; alum, 1 part. Boil.

PURPLE.—Logwood, 11 parts; alum, 3 parts; water, 29 parts. Boil.

Deer Skins.—TANNING AND BUFFING FOR GLOVES.—For each skin take a bucket of water, and put into it 1 quart of lime; let the skin or skins lie in from 3 to 4 days; then rinse in clean water, hair, and grain; then soak them in cold water to get out the glue; now scour or pound in good soap-suds for half an hour; after which take white vitriol, alum, and salt, 1 tablespoon of each to a skin; these will be dissolved in sufficient water to cover the skin, and remain in it for 24 hours; wring out as dry as convenient, and spread on with a brush ½ pint of currier's oil, and hang in the sun about two days; after which you will scour out the oil with soap-suds, and hang out again until perfectly dry; then pull and work them until they are soft; and if a reasonable time does not make them soft, scour in suds again as before, until complete. The oil may be saved by pouring or taking it from the top of the suds, if left standing for a short time. The buff color is given by spreading yellow ochre evenly over the surface of the skin, when finished, rubbing it in well with a brush.

TANNING WITH ACID.—After having removed the hair, scouring, soaking, and pounding in the suds, &c., as in the last recipe, in place of the white vitriol, alum, and salt, as there mentioned, take oil of vitriol (sulphuric acid,) and water, equal parts of each, and thoroughly wet the flesh side of the skin with it, by means of a sponge or cloth upon a stick; then folding up the skin, letting it lie for 20 minutes only, having ready a solution of sal-soda and water, say 1 lb. to a bucket of water, and soak the skin or skins in that for two hours, when you will wash in clean water, and apply a little dry salt, letting lie in the salt over night, or that length of time; then remove the flesh with a blunt knife, or, if doing business on a large scale, by means of the regular beam and flesh-knife; when dry or nearly so, soften by pulling and rubbing with the hands, and also with a piece of pumice-stone. This, of course, is the quickest

way of tanning, and by only wetting the skins with the acid, and soaking them out in 20 minutes, they are not rotted.

Another Method.—Oil of vitriol, ½ oz.; salt, 1 teacup; milk sufficient to handsomely cover the skin, not exceeding 3 qts., warm the milk, then add the salt and vitriol; stir the skin in the liquid 40 minutes, keeping it warm; then dry, and work it as directed in No. 4.

Liquid Red.—Channellers will find that no better or richer color for their purposes can be got than the red ink described under the Grocer's Department, diluted to the required shade. For color for the bottoms of shoes use tincture of red sanders.

Bridle Stain.—Skimmed milk, 1 pint; spirits of salts, ½ oz.; spts. of red lavender, ½ oz.; gum arabic, 1 oz.; and the juice of 2 lemons; mix well together, and cork for use; apply with a a sponge; when dry, polish with a brush or a piece of flannel. If wished paler, put in less red lavender.

Process of Tanning Calf, Kip, and Harness Leather in from Six to Thirty Days.—For a 12 lb. calf skin, take 3 lbs. of terra japonica, common salt 2 lbs.; alum, 1 lb.; put them into a copper kettle with sufficient water to dissolve the whole by boiling. The skin will be limed, haired, and treated every way as for the old process, when it will be put it into a vessel with sufficient water to cover it, at which time you will put in 1 pint of the composition stirring it well, adding the same amount each night and morning for 3 days, when you will add the whole, handling 2 or 3 times daily all the time tanning; you can continue to use the tanning liquid by adding half the quantity each time, by keeping these proportions for any amount. If you desire to give a bark color to the leather, you will put in 1 lb. of Sicily sumac; kip skins will require about 20 days, light house hides for harness 30 days, calf skins from 6 to 10 days at most.

To Tan Raw Hide.—When taken from the animal, spread it flesh side up; then put 2 parts of saltpetre and alum combined, make it fine, sprinkle it evenly over the surface, roll it up, let it alone a few days till dissolved; then take off what flesh remains, and nail the skin to the side of a barn in the sun; stretch tight, to make it soft like harness leather, put neat's foot oil on it, fasten it up in the sun again; then rub out all the oil you can with a wedge-shaped stick, and it is tanned with the hair on.

French Finish for Leather.—Take a common wooden pailful of scraps (the legs and pates of calf skins are best), and put a handful each of salt and alum upon them, and let them stand 3 days; then boil them until they get a thick paste; in using, you will warm it, and in the first application put a little tallow with it, and for the second time a little soft soap, and use it in the regular way of finishing, and your leather will be soft and pliable, like French leather.

French Patent Leather.—Work into the skin with appropriate tools 3 or 4 successive coatings of drying varnish, made by

boiling linseed oil with white lead and litharge, in the proportion of 1 lb. of each of the latter to 1 gal. of the former, and adding a portion of chalk or ochre, each coating being thoroughly dried before the application of the rest. Ivory black is then substituted for the chalk or ochre, the varnish thinned with spirits of turpentine, and five additional applications made in the same manner as before, except that it is put on thin and not worked in. The leather is rubbed down with pumice stone, in powder, and then placed in a room at 90 degrees, out of the way of dust. The last varnish is prepared by boiling ½ lb. of asphaltum with 10 lbs. of the drying oil used in the first stage of the process, and then stirring in 5 lbs. copal varnish and 10 lbs. of turpentine. It must have 1 month's age before using.

Cheap Tanning without Bark or Mineral Astringents.—The astringent liquor is composed of water, 17 gals.; Aleppo galls, ½ lb.; Bengal catechu, 1½ oz. and 5 lbs. of tormentil, or septfoil root. Powder the ingredients, and boil in the water 1 hour; when cool, put in the skins (which must be prepared by being plunged into a preparation of bran and water for 2 days previously); handle them frequently during the first 3 days, let them alone the next 3 days, then handle 3 or 4 times in one day; let them lie undisturbed for 25 days more, when the process will be complete.

Canadian Process.—The Canadians make 4 liquors in using the japonica.

The FIRST liquor is made by dissolving, for 20 sides of upper, 15 lbs. of terra japonica in sufficient water to cover the upper being tanned. The SECOND liquor contains the same amount of japonica, and 8 lbs. of saltpetre also. The THIRD contains 20 lbs. of japonica, and 4½ lbs. of alum. The FOURTH liquor contains only 15 lbs. of japonica, and 1½ lbs. of sulphuric acid; and the leather remains 4 days in each liquor for upper; and for sole the quantities and time are both doubled. They count 50 calf skins in place of 20 sides of upper, but let them lie in each liquor only 3 days.

Fifty Dollar Recipe for Tanning Fur and Other Skins.—Remove the legs and useless parts, soak the skin soft, and then remove the fleshy substances, and soak it in warm water one hour. Now take for each skin borax, saltpetre, and Glauber-salt, of each ½ oz. and dissolve or wet with soft water sufficient to allow it to be spread on the flesh side of the skin. Put it on with a brush, thickest in centre or the thickest part of the skin, and double the skin together, flesh side in; keeping it in a cool place for 24 hours, not allowing it to freeze. Then wash the skin clean, and take sal-soda, 1 oz.; borax, ½ oz.; refined soap, 2 oz.; melt them slowly together, being careful not to allow them to boil, and apply the mixture to the flesh side as at first. Boil up again, and keep in a warm place for 24 hours; then wash the skin clean again, as above, and have saleratus, 2 oz.; dissolved in hot rain water sufficient to well

saturate the skin; then take alum, 4 oz.; salt, 8 oz.; and dissolve also in hot rain water; when sufficiently cool to allow the handling of it without scalding, put in the skin for 12 hours; then wring out the water, and hang up for 12 hours more to dry. Repeat this last soaking and drying two or three times, according to the desired softness of the skin when finished. Lastly, finish by pulling and working, and finally by rubbing with a piece of pumice stone and fine sand paper. This works like a charm on sheep skins, fur skins, dog, wolf, bear skins, &c.

French Polish or Dressing for Leather.—Mix 2 pints best vinegar with 1 pt. soft water; stir into it ¼ lb. glue, broken up, ½ lb. logwood chips, ¼ oz. of finely powdered indigo, ¼ oz. of the best soft soap, ¼ oz. of isinglass; put the mixture over the fire, and let it boil ten minutes or more; then strain, bottle and cork. When cold, it is fit for use. Apply with a sponge.

Currier's Size.—Take of sizing, 1 qt.; soft soap, 1 gill; stuffing, 1 gill; sweet milk, ½ pt.; boil the sizing in water to a proper consistence, strain, and add the other ingredients; and when thoroughly mixed, it is ready for use.

Currier's Paste.—FIRST COAT.—Take of water, 2 qts.; flour, ½ pint; Castile soap, 1 oz.; make into paste. SECOND COAT.—Take of first paste, ½ pt.; gum tragacanth, 1 gill; water, 1 pt.; mix all together. This will finish eighteen sides of upper.

Currier's Skirting.—This is for finishing skirting and the flesh of harness leather, in imitation of oak tanning. Take of chrome yellow, ½ lb.; yellow ochre, 1 lb.; cream of tartar, 1 oz.; soda, ½ oz.; paste, 5 qts.; mix well. This will finish twelve sides.

Skirting.—For the grain to imitate oak tan. Take of chrome yellow, ½ lb.; yellow ochre, ½ lb.; cream of tartar, 1 oz.; soda, 1 oz.; paste, 2 qts.; spirits of turpentine, 1 pt.; mix well. This will finish twelve sides.

Dyes for Leather.—BLUE.—For each skin, take 1 oz. of indigo, put it into boiling water, and let it stand one night; then warm it a little, and with a brush smear the skin twice over, and finish the same as the red.

RED.—After the skin has been properly prepared with sheep, pigs' dung, &c., then take strong alum water, and sponge over your skin; when dry, boil a strong gall liquor (it cannot be too strong); then boil a strong Brazil wood liquor (the stronger the better); take a sponge, dip it into your liquor, and sponge it over your skin; repeat this till it comes to a full red. To finish your skin, take the white of eggs, and a little gum dragon, mix the two together in half a gill of water, sponge over your skin, and, when dry, polish off.

YELLOW.—1. Infuse quercitron bark in vinegar, in which put a little alum, and brush over your skins with the infusion; finish the same as the red. 2. Take 1 pt. of whisky, 4 oz. turmeric; mix them well together; when settled sponge your skins over, and finish as above.

BLACK.—Put your skin on a clean board, sponge it over with gall and sumach liquors, strong; then take a strong logwood liquor, sponge it over three or four times; then take a little copperas, mix

it in the logwood liquor; sponge it over your skin, and finish it the same as the red.

PURPLE.—First sponge with the alum liquor strong, then with logwood liquor strong; or mix them both, and boil them, and sponge with the liquor, finish the same as the red. The pleasing hues of yellow, brown, or tan color, are readily imparted to leather by the following simple process: Steep saffron in boiling water for a number of hours, wet a sponge or soft brush in the liquor, and with it smear the leather. The quantity of saffron, as well as of water, will, of course, depend on how much dye may be wanted, and their relative proportions to the depth of color required.

To Marble Books or Paper.—Marbling of books or paper is performed thus: Dissolve four ounces of gum arabic in two quarts of fair water; then provide several colors mixed with water in pots or shells, and with pencils peculiar to each color; sprinkle them by way of intermixture upon the gum water, which must be put into a trough, or some broad vessel; then, with a stick, curl them, or draw them out in streaks to as much variety as may be done. Having done this, hold your book or books close together, and only dip the edges in, on the top of the water and colors, very lightly; which done, take them off, and the plain impression of the colors, in mixture, will be upon the leaves; doing as well the ends as the front of the book in like manner, and afterwards glazing the colors.

Bookbinder's Varnish.—Shellac, eight parts; gum benzoin, 3 parts; gum mastic, two parts; bruise, and digest in alcohol, forty-eight parts; oil of lavender, one-half part. Or digest shellac, four parts; gum mastic, two parts; gum dammer and white turpentine, of each, one part; with alcohol (95 per cent.,) twenty-eight parts.

Red Sprinkle for Bookbinder's Red.—Brazil wood (ground,) 4 parts; alum, 1 part; vinegar, 4 parts; water, 4 parts. Boil until reduced to 7 parts, then add a quantity of loaf sugar and gum; bottle for use.

BLUE.—Strong sulphuric acid, 8 oz.; Spanish indigo, powdered, 2 oz.; mix in a bottle that will hold a quart, and place it in a warm bath to promote solution. For use, dilute a little to the required color in a tea-cup.

BLACK.—No better black can be procured than that made by the receipt for surface blacking, in this work, which see.

ORANGE COLOR.—Ground Brazil wood, 16 parts; annotto, 4 parts; alum, sugar, and gum arabic, each 1 part; water, 70 parts; boil, strain, and bottle.

PURPLE.—Logwood chips, 4 parts; powdered alum, 1 part; soft water, 24 parts; boil until reduced to 16 parts, and bottle for use.

GREEN.—French berries, 1 part; soft water, 8 parts. Boil and add a little powdered alum; then bring it to the required shade of green by adding liquid blue.

BROWN.—Logwood chips, 1 part; annotto, 1 part; boil in water, 6 parts; if too light, add a piece of copperas the size of a pea.

Tree Marble.—A marble in the form of trees may be done by

bending the boards a little on the centre, using the same method as the common marble, having the covers previously prepared. The end of a candle may be rubbed on different parts of the board to form knots.

RICE-MARBLE.—Color the cover with spirits of wine and turmeric, then place on rice in a regular manner, throw on a very fine sprinkle of copperas water till the cover is nearly black, and let it remain till dry. The cover may be spotted with the red liquid or potash water, very freely, before the rice is thrown off the boards.

SPOTTED MARBLE FOR BOOKS, ETC.—After the fore-edge of the book is cut, let it remain in the press, and throw on linseeds in a regular manner, sprinkle the edge with any dark color till the paper is covered, then shake off the seeds. Various colors may be used; the edge may be colored with yellow or red before throwing on the seeds, and sprinkling with blue. The seeds will make a fine fancy edge when placed very thick on different parts, with a few slightly thrown on the spaces between.

JAPAN COLORING FOR LEATHER, BOOK-COVERS, ETC.—After the book is covered and dry, color the cover with potash water mixed with a little paste; give two good coats of Brazil wash, and glaze it; put the book between the hands, allowing the boards to slope a little; dash on copperas water, then with a sponge full of red liquid press out on the back and on different parts large drops, which will run down each board and make a fine shaded red; when the cover is dry, wash it over two or three times with Brazil wash to give it a brighter color. See the various dyes for leather under that head.

To make Paper into Parchment.—To produce this transformation, take unsized paper and plunge it into a solution of two parts of concentrated sulphuric acid combined with 1 part water; withdraw it immediately, and wash it in clean water, and the change is complete. It is now fit for writing; for the acid supplies the want of size, and it becomes so strong that a strip 2 or 3 inches wide will bear from 60 to 80 lbs. weight, while a like strip of parchment will bear only about 25 lbs.

Best Cement for Aquaria.—It is the same as that used in constructing the tanks of the Zoological Gardens, London. One part, by measure, say a gill of litharge; 1 gill of plaster of Paris; 1 gill of dry, white sand; ⅓ of a gill of finely powdered resin. Sift, and keep corked tight until required for use, when it is to be made into a putty by mixing in boiled oil (linseed) with a little patent drier added. Never use it after it has been mixed (that is, with the oil) over fifteen hours. This cement can be used for marine as well as fresh-water aquaria, as it resists the action of salt water. The tank can be used immediately, but it is best to give it three or four hours to dry.

Horn in Imitation of Tortoise Shell.—First steam and then press the horn into proper shapes, and afterwards lay the following mixture on with a small brush, in imitation of the mottle of tortoise-shell: Take equal parts of quick-lime and litharge, and mix with strong soap-lees; let this remain until it is thoroughly dry; brush off, and repeat two or three times if necessary. Such parts as are required to be of a reddish brown should be covered with a mixture of whiting and the stain.

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Dyes for Ivory, Horn, and Bone.—BLACK.—1. Lay the articles for several hours in a strong solution of nitrate of silver, and expose to the light. 2. Boil the article for some time in a strained decoction of logwood, and then steep it in a solution of per-sulphate or acetate of iron. 3. Immerse frequently in ink until of sufficient depth of color.

BLUE.—1. Immerse for some time in a dilute solution of sulphate of indigo, partly saturated with potash, and it will be fully stained. 2. Steep in a strong solution of sulphate of copper.

GREEN.—1. Dip blue-stained articles for a short time in nitro-hydrochlorate of tin, and then in a hot decoction of fustic. 2. Boil in a solution of verdigris in vinegar until the desired color is obtained.

RED.—1. Dip the articles first in a tin mordant, used in dyeing, and then plunge into a hot decoction of Brazil wood—half a pound to a gallon of water—or cochineal. 2. Steep in red ink till sufficiently stained.

SCARLET.—Use lac-dye instead of the preceding.

VIOLET.—Dip in the tin mordant, and then immerse in a decoction of logwood.

YELLOW.—Boil the articles in a solution of alum, 1 lb. to ½ a gallon, then immerse for half an hour in the following mixture: Take a ½ lb. of turmeric, and a ¼ lb. of pearlash; boil in 1 gal. water: when taken from this, the bone must be again dipped in the alum solution.

Etching Fluid for Ivory.—Take dilute sulphuric acid, dilute muriatic acid, equal parts: mix. For etching varnish take white wax, 2 parts; tears of mastic, 2 parts: mix.

To Gild Ivory.—Immerse it in a solution of nitro-muriate of gold, and then expose it to hydrogen gas while damp. Wash it afterwards in clean water.

To Soften Ivory.—In 3 oz. spirits of nitre, and 15 oz. of spring water, mixed together, put your ivory to soak; and in three or four days it will obey your fingers.

To Whiten Ivory.—Slack some lime in water; put your ivory in that water, after being decanted from the grounds, and boil it till it looks quite white. To polish it afterwards, set it in the turner's wheel; and, after having worked, take rushes and pumice stones, subtile powder, with water, and rub it till it looks perfectly smooth. Next to that, heat it by turning it against a piece of linen or sheepskin leather; and, when hot, rub it over with a little whitening diluted in oil of olive; then, with a little dry whitening alone; finally with a piece of soft white rag. When all this is performed as directed, the ivory will look very white.

Another Way to Bleach Ivory.—Take 2 handfuls of lime, slake it by sprinkling it with water; then add 3 pints of water, and stir the whole together; let it settle ten minutes, and pour the water into a pan for your purpose. Then take your ivory and steep it in the lime-water for 24 hours, after which, boil it in a strong alum-water for 1 hour, and dry it in the air.

To Cut and Polish Marble.—The marble saw is a thin plate of soft iron, continually supplied, during its sawing motion, with water and the sharpest sand. The sawing of moderate pieces is performed by hand; but that of large slabs is most economically done by a proper mill. The first substance used in the polishing process is the sharpest sand, which must be worked with till the surface becomes perfectly flat. Then a second, and even a third sand, of increasing fineness is to be applied. The next substance is emery, of progressive degrees of fineness; after which, tripoli is employed; and the last polish is given with tin putty. The body with which the sand is rubbed upon the marble is usually a plate of iron; but, for the subsequent process, a plate of lead is used, with fine sand and emery. The polishing rubbers are coarse linen cloths, or bagging, wedged tight into an iron planing tool. In every step of the operation, a constant trickling supply of water is required.

Alabaster, Marble, or Stone may be stained of a yellow, red, green, blue, purple, black, or any of the compound colors, by the stains used for wood.

Powerful Cement for Broken Marble.—Take gum Arabic, 1 lb.; make into a thick mucilage; add to it powdered plaster of Paris, 1½ lbs.; sifted quick-lime, 5 oz.; mix well; heat the marble, and apply the mixture.

Seven Colors for Staining Marble.—It is necessary to heat the marble hot, but not so hot as to injure it, the proper heat being that at which the colors nearly boil. BLUE.—Alkaline indigo dye, or turnsole with alkali.

RED.—Dragon's blood in spirits of wine.

YELLOW.—Gamboge in spirits of wine.

GOLD COLOR.—Sal-ammoniac, sulphate of zinc, and verdigris, equal parts.

GREEN.—Sap green, in spirits of potash.

BROWN.—Tincture of logwood.

CRIMSON.—Alkanet root in turpentine. Marble may be veined according to taste. To stain marble *well* is a difficult operation.

Perpetual Ink for Tombstones, Etc.——Pitch, 11 lbs.; lamp-black, 1 lb.; turpentine sufficient; mix with heat.

To Clean Old Marble.—Take a bullock's gall, 1 gill of soap lees, half a gill of turpentine; make into a paste with pipe-clay, apply it to the marble; let it dry a day or two, then rub it off, and it will appear equal to new; if very dirty, repeat the application.

To Remove Grease.——Aqua ammonia, 2 oz.; soft water, 1 qt.; saltpetre, 1 teaspoonful; shaving soap in shavings, 1 oz.; mix all together; dissolve the soap well, and any grease or dirt that cannot be removed with this preparation nothing else need be tried for it.

To Clean Marble.—Take two parts of common soda, 1 part pumice stone, and 1 part of finely powdered chalk; sift it through a fine sieve, and mix it with water; then rub it well all over the marble, and the stains will be removed; then wash the marble over with soap and water, and it will be as clean as it was at first.

To make a Chemical Barometer.—Take a long, narrow bottle, and put into it $2\frac{1}{2}$ drs. of camphor; spirits of wine, 11 drs. When the camphor is dissolved, add to it the following mixture: Water, 9 drs.; saltpetre, 38 grs.; sal-ammoniac, 38 grs. Dissolve these salts in the water prior to mixing with the camphorated spirit; then shake all well together, cork the bottle well, wax the top, but afterwards make a very small aperture in the cork with a red-hot needle. By observing the different appearances which the materials assume as the weather changes, it becomes an excellent prognosticator of a coming storm or of a sunny sky.

Waterproofing for Clothing.—Boiled oil, 15 lbs.; beeswax, 1 lb.; ground litharge, 13 lbs.; mix, and apply with a brush to the article, previously stretching against a wall or on a table, previously well washing and drying each article before applying the composition.

To Renew Old Silks.—Unravel and put them in a tub, cover them with cold water, let them remain one hour; dip them up and down, but do not wring; hang up to drain, and iron while very damp, and it will look beautiful.

Potter's Invisible Waterproofing for Clothing.—Imbue the cloth on the wrong side with a solution of isinglass, alum, and soap dissolved in water, forming an emulsion of a milky thickness; apply with a brush, rubbing in well. When dry, it is brushed on the wrong side against the grain, and then gone over with a brush dipped in water; afterwards brushed down smooth.

To raise a Nap on Cloth.—Clean the article, well; soak it in cold water for half an hour; put it on a board, and rub the threadbare parts with a half-worn hatter's card filled with flocks, or with a teazle or a prickly thistle until a nap is raised; then lay the nap the right way with a hatter's brush, and hang up to dry.

Black Reviver for Cloth.—Bruised galls, 1 lb.; logwood, 2 lbs.; green vitriol, $\frac{1}{2}$ lb.; water, 5 quarts; boil two hours; strain, and it is ready for use.

Trapper's and Angler's Secret for Game and Fish.—A few drops of oil of anise, or oil rhodium, on any trapper's bait, will entice any wild animal into the snare trap. India cockle mixed with flour dough, and sprinkled on the surface of still water, will intoxicate fish, render them insensible; when coming up to the surface, they can be lifted into a tub of fresh water to revive them, when they may be used without fear.

Easy Method of Preventing Moths in Furs or Woolens.—Sprinkle the furs or woolen stuffs, as well as the drawers or boxes in which they are kept, with spirits of turpentine, the unpleasant scent of which will speedily evaporate on exposure of the stuffs to the air. Some persons place sheets of paper, moistened with spirits of turpentine, over, under, or between pieces of cloth, &c., and find it a very effectual method. Many woolen drapers put bits of camphor, the size of a nutmeg, in papers, on different parts of the shelves in their shops; and as they brush their cloths every two,

three, or four months, this keeps them free from moths; and this should be done in boxes where furs, &c., are put. A tallow candle is frequently put within each muff when laid by.

Clothing Renovator.—Soft water, 1 gal.; make a strong decoction of logwood by boiling the extract with the water. Strain; when cool, add 2 oz.; gum arabic in powder; bottle, cork well, and set aside for use; clean the coat well from grease and dirt, and apply the above liquid with a sponge evenly. Dilute to suit the color, and hang in the shade to dry; afterwards brush the nap smooth, and it will look like new.

Waterproofing for Porous Cloth.—Dissolve 2½ lbs. alum in 4 gals. water; dissolve also, in a separate vessel the same weight of acetate of lead in the same quantity of water. When both are well dissolved, mix the solutions together; and, when the sulphate of lead resulting from this mixture has been precipitated to the bottom of the vessel in the form of a powder, pour off the solution, and plunge into it the fabric to be rendered waterproof. Wash and rub it well during a few minutes, and hang it in the air to dry.

How to Write on Glass in the Sun.—Dissolve chalk in aqua fortis to the consistency of milk, and add to that a strong solution of silver. Keep this in a glass decanter well stopped. Then cut out from a paper the letters you would have appear, and paste the paper on the decanter or jar, which you are to place in the sun in such a manner that its rays may pass through the spaces cut out of the paper, and fall on the surface of the liquor. The part of the glass through which the rays pass will turn black, while that under the paper will remain white. Do not shake the bottle during the operation. Used for lettering jars.

To Transfer Prints, Etc., to Glass.—Take of gum sandarach, 4 oz.; mastic, 1 oz.; Venice turpentine, 1 oz.; alcohol, 15 oz. Digest in a bottle, frequently shaking, and it is ready for use. Directions: Use, if possible, good plate-glass of the size of the picture to be transferred, go over it with the above varnish, beginning at one side, press down the picture firmly and evenly as you proceed, so that no air can possibly lodge between; put aside, and let it dry perfectly, then moisten the paper cautiously with water, and remove it piece-meal by rubbing carefully with the fingers; if managed nicely, a complete transfer of the picture to the glass will be effected.

Paper for Photographing.—Wash the paper with a solution of nitrate of silver, 5 grs.; distilled water, ½ oz.; dry the paper, and wash it with iodide of potassium, 5 grs.; distilled water, ½ oz.; dry with a gentle heat; repeat the wash with the silver solution; and, when dry, the paper is ready for use. The sensitive surface is an iodide of silver, and is easily affected by light.

How to Photograph on Glass.—Take dry saltpetre, ½ oz.; strong oil vitriol, ¾ oz.; mix in a tumbler, add 20 grains of dry cotton wool, stir with a glass rod five minutes, remove the cotton, and

wash from all traces of the acid in four or five waters; then dry carefully under 120°. This is gun cotton. To make collodion, dissolve 20 grs. gun-cotton in 6 oz. sulphuric ether, to which add alcohol, ¾ oz.; let it stand a short time, and pour off the clear into bottle No. 1 for use. In bottle No. 2, put 1 oz. alcohol, and as much iodide of ammonium as it will dissolve; then add as much iodide of silver (made from nitrate of silver and iodide of potassium) as the solution will take up. Get another bottle, No. 3, with a wide mouth; into it put 1 oz. out of No. 1, to which add 15 or 20 drops out of No. 2. The collodion thus formed is call collodio-iodide of silver. Having well cleaned a plate of glass of the size of the frame in your camera, coat it completely and very evenly on one side, by pouring the collodion on the centre from the bottle; pour back any excess of liquid from one corner of the glass, and in this way you coat the plate in a uniform manner. To prepare the plate thus coated for the camera, plunge it carefully and quickly into a bath of the following proportions, then allow it to remain covered in the solution about two minutes: Distilled water, 1 oz.; nitrate of silver, 80 grs.; alcohol, 30 drops; dissolve and filter. Obtain a good focus, place the plate in the frame and the frame in the camera, pull up the slide in front, and expose a proper length of time; having closed your slide, remove the frame to your dark room, take out the plate. and develop the picture with the following solution, holding the plate perfectly level, the collodion side upward, and pouring enough of it on the plate to cover it; in a short time the picture will be developed: Water, 1 oz.; copperas, 14 grs.; saltpetre, 10 grs.; acetic acid, ½ drachm; nitric acid, 2 drops; then wash with water, and pour over it some of the solution of hyposulphite of soda made thus: Water, 1 pt.; hyposulphate of soda, 4 oz., allow it to remain for two minutes, then wash off thoroughly, and your picture is finished. By this process, a most beautiful picture is obtained in a space of time varying from a fraction of a second up to 15 seconds, with the most perfect detail of all the parts.

Bottle Glass.—No. 1. DARK GREEN.—Fused glauber-salts, 11 lbs.; soaper's salts, 12 lbs.; waste soap-ashes, ½ bushel; silicious sand, ½ cwt.; glass-skimmings, 22 lbs.; broken green glass, 1 cwt. to 1¼ cwt.; basalt, 25 lbs. to ¼ cwt.

No. 2. PALE GREEN.—Pale sand, 100 lbs.; kelp, 35 lbs.; lixiviated wood ashes, 1½ cwt.; fresh, do., 40 lbs.; pipe-clay, ¾ cwt.; cullet, or broken glass, 1½ cwt.

No. 3. Yellow or white sand, 120 parts; woodashes, 80 parts; pearlashes, 20 parts; common salt, 15 parts; white arsenic, 1 part; very pale.

Crystal Glass.—No. 1. Refined pot-ashes, 60 lbs.; sand, 120 lbs.; chalk, 24 lbs.; nitre and white arsenic, of each 2 lbs.; oxide of manganese, 1 to 2 oz. No. 2. Pure white sand, 120 parts; refined ashes, 70 parts; saltpetre; 10 parts; white arsenic, ½ part; oxide of manganese, ½ part. No. 3. Sand, 120 parts; red lead, 50 parts; purified pearlash, 40 parts; nitre, 20 parts; manganese, ½ part.

Flask Glass (*of St. Etienne.*)—Pure silicious sand, 61 parts; potash, 3½ parts; lime, 21 parts; heavy spar, 2 parts; oxide of manganese, q. s.

Best German Crystal Glass.—Take 120 lbs. of calcined flints or white sand; best pearl-ashes, 70 lbs.; saltpetre, 10 lbs.; arsenic, ½ lb.; and 5 oz. manganese. No. 2. (CHEAPER.) Sand or flint, 120 lbs.; pearlash, 46 lbs.; nitre, 7 lbs.; arsenic, 6 lbs.; magnesia, 5 oz. This will require a long continuance in the furnace, as do all others when much of the arsenic is used.

Plate Glass.—No. 1. Pure sand, 40 parts; dry carbonate of soda, 26½ parts; lime, 4 parts; nitre, 1½ parts; broken plate glass, 25 parts. No. 2. URE'S.—Quartz-sand, 100 parts; calcined sulphate of soda, 24 parts; lime, 20 parts; cullet of soda-glass, 12 parts. No. 3. VIENNA.—Sand, 100 parts; calcined sulphate of soda, 50 parts; lime, 20 parts; charcoal, 2¾ parts. No. 4. FRENCH.—White quartz sand and cullet, of each 300 parts; dry carbonate of soda, 100 parts; slacked lime, 43 parts.

Crown Glass.—No. 1. Sand, 300 lbs.; soda-ash, 200 lbs.; lime, 30 to 35 lbs.; 200 to 300 lbs. of broken glass. No. 2. (BOHEMIAN.)—Pure silicious sand, 63 parts; potash, 22 parts; lime, 12 parts; oxide of manganese, 1 part. No. 3. (PROF. SCHWEIGER.) Pure sand, 100 lbs.; dry sulphate of soda, 50 parts; dry quicklime in powder, 17 to 20 parts; charcoal, 4 parts. PRODUCT—White and good.

Best Window Glass.—No. 1. Take of white sand, 60 lbs.; purified pearlashes, 30 lbs.; of saltpetre, 15 lbs.; of borax, 1 lb.; of arsenic, ½ lb. This will be very clear and colorless if the ingredients be good, and will not be very dear. No. 2. (CHEAPER.)—White sand, 60 lbs.; unpurified pearlashes, 25 lbs.; of common salt, 10 lbs.; nitre, 5 lbs.; arsenic, 2 lbs.; manganese, 1½ oz. No. 3. COMMON GREEN WINDOW-GLASS.—White sand, 60 lbs.; unpurified pearlashes, 30 lbs.; common salt, 10 lbs.; arsenic, 2 lbs.; manganese, 2 oz.

Looking Glass Plate.—No. 1. Cleansed white sand, 60 lbs.; pearlashes, purified, 25 lbs.; saltpetre, 15 lbs.; borax, 7 lbs. This composition should be continued long in the fire, which should be sometimes strong, and afterwards, more moderate, that the glass may be entirely free from bubbles before it be worked. No. 2. White sand, 60 lbs.; pearl-ashes, 20 lbs.; common salt, 10 lbs.; nitre, 7 lbs.; borax, 1 lb. This glass will run with as little heat as the former; but it will be more brittle, and refract the rays of light in a greater degree. No. 3. Washed white sand, 60 lbs.; purified pearl-ashes, 25 lbs.; nitre, 15 lbs.; borax, 7 lbs. If properly managed, this glass will be colorless.

Window Glass.—No. 1. Dried sulphate of soda, 11 lbs.; soaper-salt, 10 lbs.; lixiviated soap-waste, ½ bush.; sand, 50 to 60 lbs.; glass-pot skimmings, 22 lbs.; broken *pale* green glass, 1 cwt. No. 2. (PALER).—White sand, 60 lbs.; pearlashes, 30 lbs.; common salt, 10 lbs.; arsenic, 10 lbs.; oxide of manganese, 2 to 4 oz.

No. 3. (VERY PALE.)—White sand, 60 lbs.; good potashes, 25 lbs.; common salt, 10 lbs.; nitre, 5 lbs.; arsenic, 2 lbs.; manganese; 2 to 4 oz. as required; broken *pale* window-glass, 14 lbs.

Magic Paper. — Take lard oil, or sweet oil, mixed to the consistencey of cream, with either of the following paints, the color of which is desired: Prussian blue, lamp-black, Venetian red, or chrome green, either of which should be rubbed with a knife on a plate or stone until smooth. Use rather thin but firm paper; put on with a sponge, and wipe off as dry as convenient; then lay them between uncolored paper, or between newspapers, and press by laying books or some other flat substance upon them until the surplus oil is absorbed, when it is ready for use.

To Make Grindstones from Common Sand.—River sand, 30 lbs.; shellac, 10 parts; powdered glass, 2 parts; melt in an iron pot, and cast into moulds.

Printing Rollers are made of glue and molasses, with sometimes a little Spanish white. The proportions are 1 lb. glue to 1 pint molasses. Break the glue to pieces, soak for 24 hours is sufficient, then melt with the molasses, and cast in a mould previously oiled to prevent it from sticking. When it gets hard after long use remelt it, using a little more molasses.

Savage's Printing Ink.—Pure balsam of copaiba, 9 oz.; lamp-black, 3 oz.; indigo and Prussian blue, each 5 drachms; Indian red, ¾ oz.; yellow soap, 3 oz. Miz, and grind to the utmost smoothness.

Holes in Millstones are filled with melted alum, mixing burr sand with it. If the hole is large, put some pieces of burr-mill stones in it first, and pour in melted alum. These pieces of block should be cut exactly to fit. There should be small joints, and fastened with plaster of Paris. These holes should be cut at least 4 inches deep; there is then no danger of their getting loose.

Fitting a New Back in an Old Millstone. — Block your stone up with a block of wood, having its face down until it lies even, solid, and perfectly level; then pick and scrape off all the old plaster down to the face blocks, so that none remains but what is in the joints of the face blocks; then wash these blocks, and keep them soaked with water. Keep a number of pieces of burr blocks, at the same time, soaked with water. Take a pail half filled with clean water, and mixed with 2 tablespoonfuls of glue water, boiled and dissolved; mix in with your hand plaster of Paris until it be thick enough that it will not run; and, breaking all the lumps, pour this on the stone, rubbing it in with your hand; the stone being at the same time damped; and place small pieces of stone all over the joints of the face blocks; you then, with more plaster, mixed in the

same way, but more stiff, with this and pieces of burr stones, build walls round the eye and verge 4 or 5 inches high, leaving the surface uneven and the eye larger, as it will be brought to its proper size by the last operation. It is better to build up the wall of the running stone round the verge for 3 inches without any spalls, so that the holes may be cut in to balance it. If you wish to make your stone heavier, you will take small pieces of iron, perfectly clean and free from grease, and lay them evenly all around the stone in the hollow place between the two walls just built; and with plaster mixed a little thicker than milk, pour in under and through all the crevices in the iron until the surface is nearly level with the two walls. If the stones do not require additional weight added, instead of iron use pieces of stone the same way, leaving the surface rough and uneven Again, as before, build walls round the verge of the stone, and round the eye of the stone, until they are within 2 inches of the thickness you want your stones to be, the wall round the eye being 2 inches higher than that round the verge, and filling the space between the walls with stones; and, pouring in plaster again, make it nearly level with the walls, but leaving the surface rough and jagged. to make the plaster adhere well to it. Let it stand until the back is dry and perfectly set, when you raise the stone upon its edge, and, with a trowel, plaster round the edge of the stone neatly, giving it a taper of ½ inch from the face to the back of the stone. When cased round in this way, lay the stone down on the cock-head; it being in the balance ryne, but the driver off, then raise the spindle, and balance the stone as already directed before putting on the remainder of the back. Then have a tin made the size of the eye, and to reach from the balance ryne to the thickness you want the stone to be at the eye. This tin should be exactiy fitted to its place, and made fast; then fit a hoop of wood or iron round the verge, having the upper edge of the thickness from the face you want the stone to be at the verge, and equal all round. This hoop should be greased; and all the cracks round it, and the tin in the eye, being stopped, you pour thin plaster (with more glue water then in previous operations, to prevent it from setting so quickly, and to give time to finish off the back correctly) until it be level with the hoop round the verge, and with a straight edge, one end resting on the hoop, and the other end resting on the tin at the eye; then, by moving it round, and working the plaster with a trowel, make the surface of the back even and smooth between these two points. The hoop is then taken off, and the back and edges planed smooth; then lower the spindle until your runner lies solid, and put your band or hoop on, it being first made nearly red hot, and taking care that it is of sufficient size not to require too much driving; if fitting too tightly, it may loosen the back in driving it to its proper place. It may be cooled gently by pouring water on it; and, when cool, it should fit tight.

Mill Dams.—When building a dam, you should select the most suitable place. If you can, place it across the stream near a rocky bluff, so that the ends of the dam may run into the bluff. This will prevent the water running by at the ends of the dam. Build your dam strong; if this is not done, they are breaking up often, causing ruinous expense in money and loss of time.

Rock Dams are incomparably the best in use, if there is plenty of material at hand for building, and a rock bottom to the stream; if there is not a rock bottom, you should dig a trench in the bottom, deep enongh, so that the water cannot undermine it. This should be the same as if you were building the foundation of a large building. The wall to be built should be of a small, circular form, so that the back of the circle should be next to the body of water, which may by its pressure tighten it. To secure the water from leaking through at the ends of the dam, dig a ditch deeper than the bottom of the river; then fill this with small pieces of rock, and pour in cement. This cement is made of hydraulic cement, and is made of one part cement to five parts of pure sand. It will effectually stop all crevices. A rock dam, if well built, will be perfectly tight. Use as large rock as you conveniently can move; building this wall 4 to 6 feet thick, according to the length of the dam, with jam or buttresses every place where they are needed to strengthen it. Make true joints to these rocks, especially on the ends, so that they may join close together. When you have the outside walls laid in cement, for every layer fill the middle up with pieces of small rock, pouring in your grout, so that there may not be a crevice but what is filled. If there is any crevice or hole left open, the water will break through, wearing it larger and larger. If the stream is wide and large, it is necessary to build the dam in two sections, which should be divided by a waste way, necessary for the waste or surplus water to run over, to keep the head in its proper place or height. Let each section, next to where the water is to be run over, be abutments, built to strengthen the dam. The last layer of rock, on the top where the waste water runs over, should project 5 or 6 inches over the back of the dam, so that the water may not undermine it. This last layer should be of large rocks, and jointed true; then laid in hydraulic cement, in proportion of 1 of cement to 3 of sand. When the dam is built, the front should be filled up with coarse gravel or clay; this is best done with teams, as the more it is tramped the more durable it becomes.

Frame Dams.—In building a frame dam commence with a good foundation, laying the first sills in the bottom, of sufficient depth. They should be large square timbers that will last in the water without rotting. Where there is a soft foundation, the bottom should first be made level; then dig trenches for the mud sills, about 7 or 8 feet apart, lengthways of the stream, and 10 or 12 feet long. Into these first sills other sills must be framed, and put crosswise of the stream, 6 or 8 feet apart, to reach as far across the stream as necessary. Then two outside sills should be piled down with 2-inch plank driven down to a depth of 4 or 5 feet. If this can be done conveniently, they are to be jointed as closely as possible. It would be better to line with some stuff 1 inch thick; then with posts their proper length, about 12 or 14 inches square, which should be framed into the uppermost sills, in both sides, and all the way across the dam, from bank to bank, at a distance of 6 feet apart. Then, with braces to each post, to extend two-thirds of the length of the post, where they should be joined together with a lock, instead of a mortise and tenon, with an iron bolt of 1 or 1¼ inches in diameter, going through both, and tightened with a screw and

nut. When mortises and tenons are used, they often become rotten and useless in a few days. These braces should be set at an angle of 50 or 60° with the other end mortised into the mud sill. These braces require to be about 6 to 8 inches, and as long as you find necessary; being covered with dirt, it will not decay for a long time, as the air is excluded. These posts should be capped from one to the other, plate fashion. The posts should be lined with 2 or 2½ inch plank on the inside, pinned to the plank, and should, in the middle, be filled in with dirt.

If the stream is large and wide, the dam should be built in two sections, which should be divided by a waste-way for the surplus water, which should be in the centre of the dam, and sufficient for all the waste-water to run over. Let each section of the dam form an abutment next to the waste-way, placing cells or sills 4 feet apart the length of the waste-way; in each of these sills, posts should be framed with a brace for the sides. These rows of posts, standing across the dam, will form the sectional abutments; the middle one may be constructed by being lengthways of the stream, with shore braces, so that they will not be in the way of driftwood passing down the stream; it being necessary for strong pieces for a bridge. Then cover the sills with an apron of 2-inch plank joined perfectly straight, to extend 30 or 40 feet below the dam, to prevent the undermining of the dam. The planks which are used for the purpose of lining the posts which form the abutments of each section of the dam and the ends of the waste-way, should be truly pointed, so as to prevent any leakage. The dam being built, the dirt should be filled in with teams; as the more it is tramped the better. Clay or coarse gravel is the best. Then place your gates on the upper side of the waste-way, the size that is necessary to a level with low-water mark; which gates are not to be raised except in times of high water, as the proper height of the mill-pond should be regulated by boards placed over the gate for the desired head, as the water should be allowed to pass at all times freely over them. To strengthen the dam, if you think necessary, 2-inch plank may be used in lining the front side of the dam, long enough to reach from the bottom of the stream (on an inclined plane, and next to the body of water) to the top of the dam, and filled up nearly to the top of the dam with clay or gravel well tramped down.

Brush or Log Dams are very often used in small, muddy streams. When the bottom of the stream is of a soft nature; take a flat-boat where you want to fix your dam, and drive piles the whole length of the stream, about 3 or 4 feet apart, as deep as you can. Take young oak saplings, pointed at the end, for the purpose. If you can, construct a regular pile-driver, similar to those in use for making trestle-work on the railways. The weight may be pulled up by horses instead of an engine. When you have finished driving piles, make some boxes or troughs of 2 or 3 inch plank, about 3 feet wide and as long as the plank is. Sink these in the water, the length of the dam, close to the piles, by loading them with rock, until they are at the bottom of the stream, filling in the front part of the dam with dirt and brush, nearly to the height you want it. This kind of dam will last a long time.

Whenever there is a small break in the dam or race, cut up some willows and brush, put them in the break along with some straw and dirt, and ram them down with clay.

In regard to the flume, the greatest care must be taken to insure strength and durability, combined with lightness. Every step taken in its construction must be of such a nature as to unite these qualities in the highest possible degree, otherwise the whole is, in a manner, labor lost.

To Restore Burnt Steel, and Weld Cast Steel.—Borax, 48 oz.; sal ammonic, 16 oz.; prussiate potash, 8 oz.; rosin, 4 oz.; alcohol, ½ gill; soft water, ½ pint. Put into an iron pan, and hold over a slow fire till it comes to a slow boil, and until the liquid matter evaporates, not letting it boil hard, and being careful to stir it well from the bottom all the time.

Steel may be burned till it drops apart, and the particles gathered and welded together with this composition, making it as durable as ever.

Superior Bell Metal.—Copper, 100 lbs.; tin, 23 lbs.

Electrum.—Copper, 8 nickel, 4 zinc, 3½ parts. This compound is unsurpassed for ease of workmanship and beauty of appearance.

To Write in Silver.—Mix 1 oz. of the finest pewter or block tin, and 2 oz. of quicksilver together till both become fluid, then grind it with gum water, and write with it. The writing will then look as if done with silver.

Best Bronze for Brass.—Take 1 lb. muriatic acid, and ½ lb. white arsenic. Put them into an earthen vessel, and then proceed in the usual manner.

Another Bronze for Brass.—One ounce muriate of ammonia, ½ oz. alum, ¼ oz. arsenic, dissolved all together in 1 pint of strong vinegar.

Zincing.—Copper and brass vessels may be covered with a firmly adherent layer of pure zinc by boiling them in contact with a solution of chloride of zinc, pure zinc turnings being at the same time present in considerable excess.

Dentist's Emery Wheels.—Emery, 4 lbs.; shellac, ½ lb.; melt the shellac over a slow fire; stir in the emery, and pour it into a mould of plaster of Paris. When cold it is ready for use.

Incrustation of Boilers.—(DELFOSSE'S PATENT).—If the boiler be stationary, and fed with fresh water, the amount of anti-petrifying mixture per horse power for 336 hours' consumption may be

made by mixing together 12 oz. muriate of soda, 2 drs. of dry tannic or gallic acid, 2½ oz. of hydrate of soda, or 1 or ½ oz. of subcarbonate of potash. For locomotive boilers travelling an average of 140 miles per day, the quantity of the mixture per horse power is increased one-fifth. If the water be brackish, or a mixture of salt and fresh, the muriate of soda is omitted, and instead of 12 oz., are used for 2½ oz. of hydrate of soda, and 5 drs. instead of 2 of the dry tannic or gallic extract. The mixture is also prepared in this manner when sea water is used in the boiler. The patentee prefers introducing the mixture into stationary boilers in quantities for two, three, or more days, but locomotive and marine boilers are to be supplied daily with a portion of the mixture, corresponding with the amount of duty to be performed.

To Lessen Friction in Machinery.—Grind together black lead with 4 times its weight of lard or tallow. Camphor is sometimes added (7 lbs. to the hundred weight.)

Colored Glass.—(FINE BLUE).—To 10 lbs. flint glass, previously melted and cast into water, add zaffer, 6 drs., ½ oz. of calcined copper, prepared by putting sheet copper into a crucible, and exposing it to the action of a fire not strong enough to melt the copper, and you will have the copper in scales, which you pound.

BRIGHT PURPLE.—Use 10 lbs. flint glass as before; zaffer, 5 drs.; precipitate of calcium, 1 dr.

GOLD YELLOW.—Twenty-eight pounds flint glass, and a quarter pound of the tartar which is found in urine, purify by putting it in a crucible in the fire till it smoke no more; add 2 oz. of manganese.

To Take a Plaster of Paris Cast from a Person's Face.—The person must lie on his back, and his hair be tied behind, into each nostril put a conical piece of paper open at each end to allow of breathing. The face is to be lightly oiled over, and the plaster, being properly prepared, it is to be poured over the face, taking particular care that the eyes are shut, till it is a quarter of an inch thick. In a few minutes the plaster may be removed. In this a mold is to be formed, from which a second cast is to be taken, that will furnish casts exactly like the original.

To Harden and Temper Cast Steel.—For saws and springs in general, the following is an excellent liquid: Spermaceti oil, 20 gals.; beef suet *rendered*, 20 lbs.; neat's-foot oil, 1 gallon; pitch, 1 lb.; black resin, 3 lbs. The last two articles must be previously melted together, and then added to the other ingredients, when the whole must be heated in a proper iron vessel, with a close cover fitted to it, until all moisture is evaporated, and the composition will take fire on a flaming body being presented to its surface.

Furniture Oil.—Linseed oil, 1 gallon; alkanet root, 3 oz.; rose

pink, 1 oz. Boil them together ten minutes, and strain so that the oil be quite clear.

To Cast Figures in Imitation of Ivory.—Make isinglass and brandy into a paste, with powdered egg-shells very finely ground. You may give it what color you choose; but cast it warm into your mould which you previously oil over; leave the figure in the mould till dry, and you will find on taking it out that it bears a very strong resemblance to ivory.

To Print a Picture from the Print Itself.—The page or picture is soaked in a solution, first of potassa, and then of tartaric acid. This produces a perfect diffusion of crystals of bitartrate of potassa through the texture of the unprinted part of the paper. As this salt resists oil, the ink roller may now be passed over the surface, without transferring any part of its contents except to the printed part.

To Clean Old Oil-paintings.—Dissolve a small quantity of salt in stale urine; dip a woolen cloth in the mixture, and rub the paintings over with it till they are clean; then wash them with a sponge and clean water; dry them gradually, and rub them over with a clean cloth. Should the dirt be not easily removed by the above preparation, add a small quantity of soft soap. Be very careful not to rub the paintings too hard.

To Renew Old Oil-paintings.—The blackened lights of old pictures may be instantly restored to their original hue by touching them with deutoxide of hydrogen diluted with six or eight times its weight of water. The part must be afterwards washed with a clean sponge and water.

To Lengthen Levers of Anchor-escapement Watches without Hammering or Soldering.—Cut square across with a screw-head file, a little back from the point above the fork, and, when you have thus cut into it to a sufficient depth, bend forward the desired distance the piece thus partially detached. In the event of the piece snapping off while bending—which, however, rarely happens—file down the point level with the fork, and insert a pin, English lever style.

Chain Dip Solution, for Brass Chains, &c.—Sulphuric acid, 2¼ oz; nitric acid, 2 oz.; rain-water, 2 oz.; saltpetre, 1 dr.; mix together in a glass bottle, and let stand a few hours. Apply by dipping the article into the solution quickly, and then at once wash off thoroughly, and rinse in clean rain-water and dry in saw-dust. Removes instantaneously all stains or discolorations, and gives to the article a perfectly bright appearance.

Pickle for Frosting and Whitening Silver Goods.—Sulphuric acid, 1 dr.; water, 4 oz.; heat the pickle, and immerse the silver

in until frosted as desired; then wash off clean, and dry with a soft linen cloth, or in fine clean saw-dust. For whitening only, a smaller proportion of acid may be used.

Etruscan Gold Coloring.—Alum, 1 oz.; fine table-salt, 1 oz.; saltpetre (powdered,) 2 oz.; hot rain-water, sufficient to make the solution, when dissolved, about the consistency of thick ale; then add sufficient muriatic acid to produce the color desired. The degree of success must always depend, in a greater or less degree, upon the skill or judgment of the operator. The article to be colored should be from fourteen to eighteen carats fine, of pure gold and copper only, and be free from coatings of tin or silver solder. The solution is best used warm, and when freshly made the principle on which it acts is to eat out the copper alloy from the surface of the article, leaving thereon pure, frosted gold only. After coloring, wash off, first in rain-water, then in alcohol, and dry without rubbing, in fine, clean saw-dust. Fine Etruscan jewelry that has been defaced or tarnished by use may be perfectly renewed by the same process.

Tarnish on Electro-plated Ware may be removed by immersing the article from one to ten or fifteen minutes, or until the tarnish has been removed, but no longer, in the following solution: Rain-water, 2 gals.; cyanuret potassa, ½ lb.; dissolve, and put into a stone jug or jar and closely cork. After immersion, the articles must be taken out and thoroughly rinsed in two or three waters, then dried with a soft linen cloth, or, if frosted or chased work, with fine, clean saw-dust. Tarnished jewelry may be speedily restored by this process; but make sure work of removing the alkali. otherwise it will corrode the goods.

A Bright Gold Tinge may be given to silver by steeping it for a suitable length of time in a weak solution of sulphuric acid and water strongly impregnated with iron-rust.

To Make a Diamond Mill.—Make a brass chuck or wheel, suitable for use on a foot-lathe, with a flat, even surface or face of about 1½ or 2 inches in diameter; then place a number of the coarsest pieces of your diamond-dust on different parts of its face, and with a smooth-faced steel hammer drive the pieces of dust all evenly into the brass to nearly or quite level with the surface. Your mill, thus prepared, is now used for making pallet jewels or for grinding stone and glass of any kind. For polishing, use a bone or boxwood chuck or wheel, of similar form to your mill, and coat it lightly with the finest grade of your diamond-dust and oil; with this a beautiful polish may be given to the hardest stone.

To Temper Case and other Springs of Watches.—Draw the temper from the spring, and fit it properly in its place in the watch; then take it out and temper it hard in rain-water (the addition of a little table-salt to the water will be an improvement;) after which place it in a small sheet-iron ladle or cup and barely cover it with linseed

oil; then hold he ladle over a lighted lamp until the oil ignites; let it burn until the oil is nearly, not quite all, consumed; then re-cover with oil and burn down as before; and so a third time; at the end of which, plunge it again into water. Main and hair springs may, in like manner, be tempered by the same process: first draw the temper, and properly coil and clamp to keep in position, and then proceed the same as with case springs.

To Make Red Watch Hands.——1 oz. carmine, 1oz. muriate of silver, ½ oz. tinner's japan; mix together in an earthen vessel, and hold over a spirit-lamp until formed into a paste. Apply this to the watch hand, and then lay it on a copper plate, face side up, and heat the plate sufficiently to produce the color desired.

To Drill into Hard Steel.—Make your drill oval in form, instead of the usual pointed shape, and temper as hard as it will bear without breaking; then roughen the surface where you desire to drill with a little diluted muriatic acid, and, instead of oil, use turpentine or kerosene, in which a little gum camphor has been dissolved, with your drill. In operating, keep the pressure on your drill firm and steady; and if the bottom of the hole should chance to become burnished, so that the drill will not act, as sometimes happens, again roughen with diluted acid as before; then clean out the hole carefully, and proceed again.

To Case-harden Iron.—If you desire to harden to any considerable depth, put the article into a crucible with cyanide of potash, cover over and heat altogether, then plunge into water. This process will harden perfectly to the depth of two or three inches.

To Put Teeth in a Watch or Clock Wheels without Dovetailing or Soldering.—Drill a hole somewhat wider than the tooth square through the plate, a little below the base of the tooth; cut from the edge of the wheel square down to the hole already drilled; then flatten a piece of wire so as to fit snugly into the cut of the saw, and with a light hammer form a head on it like the head of a pin. When thus prepared, press the wire or pin into position in the wheel, the head filling the hole drilled through the plate, and the end projecting out so as to form the tooth; then with a sharp pointed graver cut a small groove each side of the pin from the edge of the wheel down to the hole, and with a blow of your hammer spread the face of the pin so as to fill the grooves just cut. Repeat the same operation on the other side of the wheel, and finish off in the usual way. The tooth will be found perfectly riveted in on every side, and as strong as the original one, while in appearance it will be equal to the best dovetailing.

To Tighten a Cannon Pinion on the Centre Arbor when too Loose.—Grasp the arbor lightly with a pair of cutting nippers, and, by a single turn of the nippers around the arbor, cut or raise a small thread thereon.

Jeweller's Alloys.—EIGHTEEN CARAT GOLD FOR RINGS.—Gold coin, 19½ grs.; pure copper, 3 grs.; pure silver, 1½ grs.

CHEAP GOLD, TWELVE CARAT.—Gold coin, 25 grs.; pure copper, 13½ grs.; pure silver, 7⅓ grs.

VERY CHEAP FOUR CARAT GOLD.—Copper, 18 parts; gold, 4 parts; silver, 2 parts.

IMITATIONS OF GOLD.—1. Platina, 4 dwt.; pure copper, 2¼ dwt.; sheet-zinc, 1 dwt.; block-tin, 1¾ dwt.; pure lead, 1½ dwt. If this should be found too hard or brittle for practical use, re-melting the composition with a little sal-ammoniac will generally render it malleable as desired. 2. Platina, 2 parts; silver, 1 part; copper, 3 parts. These compositions, when properly prepared, so nearly resemble pure gold that it is very difficult to distinguish them therefrom. A little powdered charcoal mixed with metals while melting will be found of service.

BEST OROIDE OF GOLD.—Pure copper, 4 oz.; sheet zinc, 1¾ oz.; magnesia, ⅝ oz.; sal-ammoniac, ½ oz.; quicklime, 9-32 oz.; cream tartar, ⅞ oz. First melt the copper at as low a temperature as it will melt; then add the zinc, and afterwards the other articles, in powder, in the order named. Use a charcoal fire to melt these metals.

Bushing Alloy for Pivot Holes, &c.—Gold coin, 3 dwt.; silver, 1 dwt., 20 grs.; copper, 3 dwt., 20 grs.; palladium, 1 dwt. The best composition known for the purpose named.

Gold Solder for Fourteen to Sixteen-Carat Work.—Gold coin, 1 dwt.; pure silver, 9 grs.; pure copper, 6 grs.; brass, 3 grs.

DARKER SOLDER.—Gold coin, 1 dwt.; pure copper, 8 grs.; pure silver, 5 grs.; brass, 2 grs.; melt together in charcoal fire.

The Northern-Light Burning Fluid.—COSTS ABOUT EIGHT CENTS PER GALLON.—Get good deodorized benzine, 60 to 65 gravity, and to each barrel of 42 gals. add 2 lbs. pulverized alum, 3½ oz. gum camphor, and 3½ oz. oil of sassafras, or 2 oz. oil bergamot; stir up and mix thoroughly together and it will soon be ready for use.

N. B.—As this fluid creates a much larger volume of light and flame than carbon oil, it is necessary to use either a high burner, such as the Sun burner, to elevate the flame away from the lamp, in order to keep it cool, or, instead thereof, to use a burner provided with a tube for the escape of the gas generated from the fluid, such, for instance, as the Meridian burner.

To Reduce Oxide of Zinc.—The oxide may be put in quantities of 500 or 600 lbs. weight into a large pot over the fire; pour a sufficient quantity of muriatic acid over the top, to act as a flux, and

the action of the fire will melt the dross, when the pure metal will be found at the bottom of the pot.

New Process to Restore Burnt Steel.—When your steel is burnt, immerse it immediately, for a very short time, in cold water; then hammer it on the anvil, turning, moving, and otherwise manipulating it while undergoing this treatment. A little dexterous practice will soon enable you to restore steel, by this beautiful and simple process, that would otherwise be hopelessly ruined.

To Remove Rust from Iron or Steel.—For cleaning purposes, &c., kerosene oil or benzine are probably the best things known. When articles have become pitted by rust, however, these can, of course, only be removed by mechanical means, such as scouring with fine powder, or flour of emery and oil, or with very fine emery paper. To prevent steel from rusting, rub it with a mixture of lime and oil, or with mercurial ointment, either of which will be found valuable.

To Restore Frozen Silver Solution.—If it is the whitening solution, add 10 pennyweights of cyanide of potassium to a pint of the solution. For the first, or hard coat solution, add about double the above quantity.

On Watch Cleaning.—It is hardly necessary to say that great caution must be observed in taking the watch down—that is, in separating its parts. If you are new at the business think before you act, and then act slowly. Take off the hands carefully so as not to bend the slender pivots upon which they work; this will be the first step. 2. Loosen and lift the movement from the case. 3. Remove the dial and dial wheels. 4. Let down the main-spring by placing your bench key upon the arbor, or "winding post," and turning as though you were going to wind the watch until the click rests lightly upon the ratchet; then with your screw-driver press the point of the click away from the teeth, and ease down the springs. 5. Draw the screws (or pins) and remove the bridges of the train, or the upper plate, as the case may be. 6. Take out the balance. Great care must be observed in this or you will injure the hair-spring. The stud or little square post into which the hair-spring is fastened may be removed from the bridge or plate of most modern watches, without unkeying the spring, by slipping a thin instrument, as the edge of a knife blade, under the corner of it and prying upward. This will save you a considerable amount of trouble, as you will not have the hair-spring to adjust when you reset the balance.

If the watch upon which you propose to work has an upper plate, as an American or an English lever, for instance, loosen the lever before you have entirely separated the plates, otherwise it will hang and most likely be broken.

Having the machine now down, brush the dust from its different parts and subject them to a careful examination with your eye-glass. Assure yourself that the teeth of the wheels and leaves of

the pinions are all perfect and smooth; that the pivots are all straight, round and highly polished, that the holes through which they are to work are not too large, and have not become oval in shape; that every jewel is smooth and perfectly sound; and that none of them are loose in their settings. See, also, that the escapement is not too deep or too shallow; that the lever or cylinder is perfect; that all the wheels have sufficient play to avoid friction, but not enough to derange their coming together properly; that none of them work against the pillar-plate; that the balance turns horizontally and does not rub; that the hair-spring is not bent or wrongly set so that the coils rub on each other, on the plate, or on the balance; in short, that everything about the whole movement is just as reason would teach you it should be. If you find it otherwise, proceed to repair in accordance with a carefully weighed judgment, and the processes given in the next chapter, after which clean--if not the watch only needs to be cleaned, and therefore you may go ahead with your work at once.

TO CLEAN.—Many watchmakers wet the pillar-plates and bridges with saliva, and then dipping the brush into pulverized chalk or Spanish whiting, rub vigorously until they appear bright. This is not a good plan, as it tends to remove the plating and roughen the parts, and the chalk gets into the holes and damages them, or sticks around the edges of the wheel-beds. The best process is to simply blow your breath upon the plate or bridge to be cleaned, and then to use your brush with a little prepared chalk—(See recipe for preparing it.) The wheels and bridges should be held between the thumb and finger in a piece of soft paper while undergoing the process; otherwise the oil from the skin will prevent their becoming clean. The pinions may be cleaned by sinking them several times into a piece of pith, and the holes by turning a nicely shaped piece of pivot wood into them, first dry and afterwards oiled a very little with watch oil. When the holes pass through jewels you must work gently to avoid breaking them.

The oiling above named is all the watch will need. A great fault with many watchmakers lies in their use of too much oil.

THE CHEMICAL PROCESS.—Some watchmakers employ what they call the "Chemical Process" to clean and remove discolorations from watch movements. It is as follows:

Remove the screws and other steel parts; then dampen with a solution of oxalic acid and water. Let it remain a few moments, after which immerse in a solution made of one-fourth pound cyanuret potassa to one gallon rain water. Let remain about five minutes, and then rinse well with clean water, after which you may dry in sawdust, or with a brush and prepared chalk, as suits your convenience. This gives the work an excellent appearance.

To Prepare Chalk for Cleaning.—Pulverize your chalk thoroughly, and then mix it with clear rain water in the proportion of two pounds to the gallon. Stir well and then let stand about two minutes. In this time the gritty matter will have settled to the bottom. Pour the water into another vessel, slowly so as not to stir up the settlings. Let stand until entirely settled, and then pour off

as before. The settlings in the second vessel will be your prepared chalk, ready for use as soon as dried.

Spanish whiting treated in the same way makes a very good cleaning or polishing powder. Some operatives add a little jeweler's rouge, and we think it an improvement; it gives the powder a nice color at least, and therefore adds to its importance in the eyes of the uninitiated. In cases where a sharper polishing powder is required, it may be prepared in the same way from rotten stone.

Pivot Wood.—Watchmakers usually buy this article of watch-material dealers. A small shrub known as Indian arrow-wood, to be met with in the Northern and Western States, makes an excellent pivot wood. It must be cut when the sap is down, and split into quarters so as to throw the pith outside of the rod.

Pith for Cleaning.—The stalk of the common mullen affords the best pith for cleaning pinions. Winter, when the stalk is dry, is the time to gather it. Some use cork instead of pith, but it is inferior.

To Pivot.—When you find a pivot broken, you will hardly be at a loss to understand that the easiest mode of repairing the damage is to drill into the end of the pinion or staff, as the case may be, and having inserted a new pivot, turn it down to the proper proportions. This is by no means a difficult thing when the piece to be drilled is not too hard, or when the temper may be slightly drawn without injury to the other parts of the article.

To Tell when the Lever is of Proper Length.—You may readily learn whether or not a lever is of proper length, by measuring from the guard point to the pallet staff, and then comparing with the roller or ruby-pin table; the diameter of the table should always be just half the length measured on the lever. The rule will work both ways, and may be useful in cases when a new ruby-pin table has to be supplied.

To Change Depth of Lever Escapement.—If you are operating on a fine watch the best plan is to put a new staff into the lever, cutting its pivots a little to one side—just as far as you desire to change the escapement. Common watches will not, of course, justify so much trouble. The usual process in their case is to knock out the staff, and with a small file cut the hole oblong in a direction opposite to that in which you desire to move your pallets; then replace the staff, wedge it to the required position, and secure by soft soldering.

In instances where the staff is put in with a screw you will have to proceed differently. Take out the staff, pry the pallets from the lever, file the pin holes to slant in the direction you would move the pallets, without changing their size on the other side of the lever. Connect the pieces as they were before, and

with the lever resting on some solid substance you may strike lightly with your hammer until the bending of the pins will allow the pallets to pass into position.

To Tell when the Lever Pallets are of Proper Size.—The clear space between the pallets should correspond with the outside measure, on the points, of three teeth of the scape wheel. The usual mode of measuring for new pallets is to set the wheel as close as possible to free itself when in motion. You can arrange it in your depthing tool, after which a measurement between the pivot holes of the two pieces, on the pillar plate, will show you exactly what is required.

To Put Watches in Beat.—If a cylinder escapement, or a detached lever, put the balance into a position; then turn the regulator so that it will point directly to the pivot-hole of the pallet staff, if a lever, or of the scape-wheel, if a cylinder. Then lift out the balance with its bridge or clock, turn it over and set the ruby-pin directly in the line with the regulator, or the square cut of the cylinder at right angles with it. Your watch will then be in perfect beat.

In case of an American or an English lever, when the regulator is placed upon the plate, you will have to proceed differently. Fix the balance into its place, cut off the connection of the train, if the mainspring is not entirely down, by slipping a fine broach into one of the wheels, look between the plates and ascertain how the lever stands. If the end furthest from the balance is equi-distant between the two brass pins it is all right—if not, change the hair-spring till it becomes so.

If dealing with a duplex watch, you must see that the roller notch, when the balance is at rest is exactly between the locking tooth and the line of centre—that is, a line drawn from the centre of the roller to the centre of the scape-wheel. The balance must start from its rest and move through an arc of about ten degrees before bringing the locking tooth into action.

To Prevent a Chain Running off the Fusee.—In the first place you must look after and ascertain the cause of the difficulty. If it results from the chain's being too large, the only difficulty is a new chain. If it is not too large, and yet runs off without any apparent cause, change it end for end—that will generally make it go all right. In cases where the channel in the fusee has been damaged and is rough, you will be under the necessity of dressing it over with a file the proper size and shape. Sometimes you find the chain naturally inclined to work away from the body of the fusee. The best way to remedy a difficulty of this kind is to file off a very little from the outer lower edge of the chain the entire length—this, as you can see, will incline it to work on instead of off. Some workmen, when they have a bad case, and a common watch, change the standing of the fusee so as to cause the winding end of its arbor to incline a little from the barrel. This, of course, cannot do otherwise than make the chain run to its place.

To Weaken the Hair-Spring.—This is often effected by grinding the spring down. You remove the spring from the coilet, and place it upon a piece of pivot wood cut to fit the centre coil. A piece of soft steel wire, flattened so as to pass freely between the coils, and armed with a little pulverized oil stone and oil, will serve as your grinder, and with it you may soon reduce the strength of the spring. Your operations will, of course, be confined to the centre coil, for no other part of the spring will rest sufficiently against the wood to enable you to grind it, but this will generally suffice. The effect will be more rapid than one would suppose, therefore it will stand you in hand to be careful or you may get the spring too weak before you suspect it.

To Tighten a Ruby Pin.—Set the ruby pin in asphaltum varnish. It will become hard in a few minutes, and be much firmer and better than gum shellac, as generally used.

To Temper Brass or to Draw its Temper.—Brass is rendered hard by hammering or rolling, therefore when you make a thing of brass, necessary to be in temper, you must prepare the material before shaping the article. Temper may be drawn from brass by heating it to a cherry red, and then simply plunging it into water the same as though you were going to temper steel.

To Temper Drills.—Select none but the finest and best steel for your drills. In making them never heat higher than a cherry red, and always hammer till nearly cold. Do all your hammering in one way, for if, after you have flattened your piece out, you attempt to hammer it back to a square or a round you spoil it. When your drill is in proper shape heat it to a cherry red, and thrust it into a piece of resin, or into quicksilver.

Some use a solution of cyanuret potassa and rain water for tempering their drills, but for my part I have always found the resin or quicksilver to work best.

To Temper Gravers.—Gravers and other instruments larger than drills, may be tempered in quicksilver as above; or you may use lead instead of quicksilver. Cut down into the lead, say half an inch; then, having heated your instrument to a light cherry red, press it firmly into the cut. The lead will melt around it, and an excellent temper will be imparted.

Other Methods to Temper Case Springs.—Having fitted the spring into the case according to your liking, temper it hard by heating and plunging into water. Next polish the small end so that you may be able to see when the color changes; lay it on a piece of copper or brass plate, and hold the plate over your lamp, with the blaze directly under the largest part of the spring. Watch the polished part of the steel closely, and when you see it turn blue remove the plate from the lamp, letting all cool gradually together. When cool enough to handle polish the end of the spring again,

place it on the plate and hold it over the lamp as before. The third blueing of the polished end will leave the spring in proper temper. Any steel article to which you desire to give a spring temper may be treated in the same way.

Another process said to be good, is to temper the spring as in the first instance; then put it in a small iron ladle, cover it with linseed oil and hold over a lamp till the oil takes fire. Remove the ladle, but let the oil continue to burn until nearly all consumed, when blow out, re-cover with oil and hold over the lamp as before. The third burning out of the oil will leave the spring in the right temper.

To Temper Clicks, Ratchets, &c.—Clicks, Ratchets, or other steel articles requiring a similar degree of hardness should be tempered in mercurial ointment. The process consists in simply heating to a cherry red and plunging into the ointment. No other mode will combine toughness and hardness to such an extent.

To Draw the Temper from Delicate Steel Pieces without Springing them.—Place the article from which you desire to draw the temper into a common iron clock key. Fill around it with brass or iron filings, and then plug up the open end with a steel, iron or brass plug, made to fit closely. Take the handle of the key with your plyers and hold its pipe into the blaze of a lamp till near hot, then let it cool gradually. When sufficiently cold to handle, remove the plug, and you will find the article with its temper fully drawn, but in all other respects just as it was before.

You will understand the reason for having the article thus plugged up while passing it through the heating and cooling process, when we tell you that springing always results from the action of changeable currents of atmosphere. The temper may be drawn from cylinders, staffs, pinions, or any other delicate pieces by this mode with perfect safety.

To Temper Staffs, Cylinders or Pinions, without Springing them.—Prepare the articles as in the preceding process, using a steel plug. Having heated the key-pipe to a cherry red, plunge it into water; then polish the end of your steel plug, place the key upon a plate of brass or copper, and hold it over your lamp with the blaze immediately under the pipe till the polished part becomes blue. Let cool gradually, then polish again. Blue and cool a second time, and the work will be done.

To Draw the Temper from Part of a Small Steel Article.—Hold the part from which you wish to draw the temper, with a pair of tweezers, and with your blow-pipe direct the flame upon them—not the article—till sufficient heat is communicated to the article to produce the desired effect.

To Blue Screws Evenly.—Take an old watch barrel and drill as many holes into the head of it as you desire to blue screws at a time. Fill it about one-fourth full of brass or iron filings, put in the

head, and then fit a wire, long enough to bend over for a handle, into the arbor holes—head of the barrel upwards. Brighten the heads of your screws, set them, point downwards, into the holes already drilled, and expose the bottom of the barrel to your lamp till the screws assume the color you wish.

To Remove Blueing from Steel.—Immerse in a pickle composed of equal parts muriatic acid and elixir vitriol. Rinse in pure water and dry in tissue paper.

To Make Diamond Broaches.—Make your broaches of brass the size and shape you desire; then, having oiled them slightly, roll their points into fine diamond dust till entirely covered. Hold them then on the face of your anvil and tap with a light hammer till the grains disappear in the brass. Great caution will be necessary in this operation. Do not tap heavy enough to flatten the broach. Very light blows are all that will be required; the grains will be driven in much sooner than one would imagine.

Some roll the broach between two smooth pieces of steel to imbed the diamond dust. It is a very good way, but somewhat more wasteful of the dust.

Broaches made on this plan are used for dressing out jewels.

To Make Polishing Broaches.—These are usually made of ivory, and used with diamond dust, loose, instead of having been driven in. You oil the broach lightly, dip it into the finest diamond dust and proceed to work into the jewel the same as you do the brass broach. Unfortunately, too many watchmakers fail to attach sufficient importance to the polishing broach. The sluggish motion of watches now-a-days, is more often attributable to rough jewels than to any other cause.

To Make Diamond Files.—Shape your file of brass, and charge with diamond dust, as in the case of the mill. Grade the dust in accordance with the coarse or fine character of the file desired.

To Make Pivot Files.—Dress up a piece of wood file-fashion, about an inch brood, and glue a piece of fine emery paper upon it. Shape your file then, os you wish it, of the best cast steel, and before tempering pass your emery paper heavily across it several times, diagonally. Temper by heating to a cherry red, and, plunging into linseed oil. Old worn pivot files may be made over and made new by this process. At first thought one would be led to regard them too slightly cut to work well, but not so. They dress a pivot more rapidly than any other file.

To Make Burnishers.—Proceed the same as in making pivot files, with the exception that you are to use fine flour of emery on a slip of oiled brass or copper, instead of the emery paper. Burnishers which have become too smooth may be improved vastly with the flour of emery as above without drawing the temper.

To Prepare a Burnisher for Polishing.—Melt a little beeswax on the face of your burnisher. Its effect then, on brass or other finer metals, will be equal to the best buff. A small burnisher prepared in this way is the very thing with which to polish up watch wheels. Rest them on a piece of pith while polishing.

To Clean a Clock. — Take the movement of the clock "to-pieces." Brush the wheels and pinions thoroughly with a stiff, coarse brush; also the plates into which the trains work. Clean the pivots well by turning in a piece of cotton cloth held tightly between your thumb and finger, The pivot holes in the plates are generally cleansed by turning a piece of wood in them, but I have always found a strip of cloth or a soft cord drawn lightly through them to act the best. If you use two cords, the first one slightly oiled, and the next dry to clean the oil out, all the better. Do not use salt or acid to clean your clock—it can do no good, but may do a great deal of harm. Boiling the movement in water, as some practice, is also foolishness.

To Bush.—The hole through which the great arbors or winding axles work, are the only ones that usually require bushing. When they have become too much worn the great wheel on the axle before-named strikes too deeply into the pinions above it, and stop the clock. To remedy this bushing is necessary, of course. The most common way of doing it is to drive a steel point or punch into the plate just above the axle hole, thus forcing the brass downward until the hole is reduced to its original size. Another mode is to solder a piece of brass upon the plate in such a position as to hold the axle down to its proper place. If you simply wish your clock to run, and have no ambition to produce a bush that will look workmanlike, about as good a way as any is to fit a piece of hard wood beetween the post which comes through the top of the plate and the axle. Make it long enough to hold the axle to its proper place, and so that the axle will run on the end of the grain. Cut notches where the pivots come through, and secure by wrapping around it and the plate a piece of small wire, or a thread. There is no post coming through above the axle on the striking side. but this will rarely require bushing. I have known clocks to run well on this kind of bushing, botchified as it may appear, for ten years.

To Remedy Worn Pinions.—Turn the leaves or rollers so the worn places upon them will be towards the arbor or shaft, and fasten them in that position. If they are "rolling pinions," and you cannot secure them otherwise, you had better do it with a little soft solder.

To Oil Properly.—Oil only, and very lightly, the pallets of the verge, the steel pin upon which the verge works, and the point where the loop of the verge wire works over the pendulum wire. Use none but the best watch oil. Though you might be working constantly at the clock repairing business, a bottle costing you but 25 cents, would last you two years at least. You can buy it at any watch-furnishing establishment.

To Make the Clock Strike Correctly.—If not very cautious in putting up your clock you will get some of the striking-train wheels in wrong, and thus produce a derangement in the striking. If this should happen, pry the plates apart on the striking side, slip the pivots of the upper wheels out, and having disconnected them from the train, turn them part around and put them back. If still not right, repeat the experiment. A few efforts at most will get them to working properly.

A Defect to Look After.—Always examine the pendulum-wire at the point where the loop of the verge wire works over it. You will generally find a small notch, or at least a rough place worn there. Dress it out perfectly smooth, or your clock will not be likely to work well. Small as this defect may seem, it stops a large number of clocks.

To Refine Gold.—If you desire to refine your gold from the baser metals, swedge or roll it out very thin, then cut into narrow strips and curl up so as to prevent its lying flatly. Drop the pieces thus prepared into a vessel containing good nitric acid, in the proportion of acid 2 oz., and pure rain water ½ oz. Suffer to remain until thoroughly dissolved, which will be the case in ½ hour to 1 hour. Then pour off the liquid carefully and you will find the gold in the form of a yellow powder lying at the bottom of the vessel. Wash this with pure water till it ceases to have an acid taste, after which you may melt and cast into any form you choose. Gold treated in this way may be relied on as perfectly pure.

In melting gold use none other than a charcoal fire, and during the process sprinkle saltpetre and potash into the crucible occasionally. Do not attempt to melt with stone coal, as it renders the metal brittle and otherwise imperfect.

To Refine Silver.—Dissolve in nitric acid as in the case of the gold. When the silver has entirely disappeared, add to the water. Sink, then, a sheet of clean copper into it—the silver will collect rapidly upon the copper, and you can scrape it off and melt into bulk at pleasure.

In the event you were refining gold in accordance with the foregoing formula, and the impurity was silver, the only steps necessary to save the latter would be to add the above-named proportion of water to the solution poured from the gold, and then to proceed with your copper plate as just directed.

To Refine Copper.—This process differs from the one employed to refine silver in no respects save the place to be immersed; you use an iron instead of a copper plate to collect the metal.

If the impurities of gold refined were both silver and copper, you might, after saving the silver as above directed, sink your iron plate into the solution yet remaining, and take out the copper. The parts of alloyed gold may be separated by these processes, and leave each in a perfectly pure state.

To Hard Solder Gold, Silver, Copper, Brass, Iron, Steel, or Platina.—The solders to be used for gold, silver, copper and brass are given in the preceding part. You commence operations by reducing your solder to small particles and mixing it with powdered sal-ammoniac and powdered borax in equal parts, moistened to make it hold together. Having fitted up the joint to be soldered, you secure the article upon a piece of soft charcoal, lay your soldering mixture immediately over the joint, and then with your blow pipe turn the flames of your lamp upon it until fusion takes place. The job is then done and ready to be cooled and dressed up.

Iron is usually soldered with copper or brass, in accordance with the above process. The best solder for steel is pure gold or pure silver, though gold or silver solders are often used successfully.

Platina can only be soldered well with gold; and the expense of it, therefore, contributes to the hindrance of a general use of platina vessels, even for chemical purposes, where they are of so much importance.

To Soft Solder Articles.—Moisten the parts to be united with soldering fluid; then, having joined them together, lay a small piece of solder upon the joint and hold over your lamp, or direct the blaze upon it with your blow pipe until fusion is apparent. Withdraw them from the blaze immediately, as too much heat will render the solder brittle and unsatisfactory. When the parts to be joined can be made to spring or press against each other, it is best to place a thin piece of solder between them before exposing to the lamp.

Where two smooth surfaces are to be soldered one upon the other, you may make an excellent job by moistening them with the fluid, and then, having placed a sheet of tin foil between them, holding them pressed firmly together over your lamp till the foil melts. If the surfaces fit nicely a joint may be made in this way so close as to be almost imperceptible. The brightest looking lead which comes as a lining to tin boxes works better in the same way than tin foil.

To Cleanse Gold Tarnished in Soldering.—The old English mode was to expose all parts of the article to a uniform heat, allow it to cool and then boil until bright in urine and sal-ammoniac. It is now usually cleansed with diluted sulphuric acid. The pickle is made in about the proportion of one-eighth of an oz. acid to 1 oz. rain water.

To Cleanse Silver Tarnished in Soldering.—Some expose to a uniform heat, as in the case of gold, and then boil in strong alum water. Others immerse for a considerable length of time in a liquid made of ½ an oz. of cyanuret potassa to 1 pt. rain water, and then brush off with prepared chalk.

To Make Gold Solution for Electro-Plating.—Dissolve five pennyweights gold coin, five grains pure copper and 4 grains pure silver in 3 oz. nitro muriatic acid; which is simply two parts muria-

tic acid and one part nitric acid. The silver will not be taken into solution as are the other two metals, but will gather at the bottom of the vessel. Add 1 oz. pulverized sulphate of iron, ½ oz. pulverized borax, 25 grs. pure table salt, and 1 qt. hot rain water. Upon this the gold and copper will be thrown to the bottom of the vessel with the silver. Let stand till fully settled, then pour off the liquid carefully, and refill with boiling rain water as before Continue to repeat this operation until the precipitate is thoroughly washed; or, in other words, fill up, let settle, and pour off so long as the accumulation at the bottom of the vessel is acid to the taste.

You now have about an eighteen carat chloride of gold. Add to it an oz. and an eighth cyanuret potassa, and 1 qt. rain water—the latter heated to the boiling point. Shake up well, then let stand about twenty-four hours and it will be ready for use.

Some use platina as an alloy instead of silver, under the impression that plating done with it is harder. I have used both, but never could see much difference.

Solution for a darker colored plate to imitate Guinea gold may be made by adding to the above 1 oz. of dragon's blood and five grains of iodide of iron.

If you desire an alloyed plate, proceed as first directed, without the silver or copper, and with an oz. and a half of sulphuret potassa in place of the iron, borax and salt.

To Make Silver Solution for Electro-Plating.—Put together into a glass vessel, one oz. good silver, made thin and cut into strips; two oz. best nitric acid and ½ an oz. pure rain water. If solution does not begin at once, add a little more water—continue to add a very little at a time till it does. In the event it starts off well, but stops before the silver is fully dissolved, you may generally start it up again all right by adding a little more water.

When solution is entirely effected, add 1 qt. warm rain water and a large tablespoonful of table salt. Shake well and let settle, then proceed to pour off and wash through other waters as in the case of the gold preparation. When no longer acid to the taste, put in an oz. and an eighth cyanuret potassa and a qt. pure rain water; after standing about twenty-four hours it will be ready for use.

To Plate with a Battery.—If the plate is to be gold, use the gold solution for electroplating; if silver use the silver solution. Prepare the article to be plated by immersing it for several minutes in a strong lye made of potash and rain water, polishing off thoroughly at the end of the time with a soft brush and prepared chalk. Care should be taken not to let the fingers come in contact with the article while polishing, as that has a tendency to prevent the plate from adhering—it should be held in two or three thicknesses of tissue paper.

Attach the article, when thoroughly cleansed, to the positive pole of your battery, then affix a piece of gold or silver, as the case may be, to the negative pole, and immerse both into the solution in such a way as not to hang in contact with each other.

After the article has been exposed to the action of the battery about ten minutes, take it out and wash or polish over with a thick

mixture of water and prepared chalk or jeweller's rouge. If, in the operation, you find places where the plating seems inclined to peel off, or when it has not taken well, mix a little of the plating solution with prepared chalk or rouge, and rub the defective part thoroughly with it. This will be likely to set all right.

Govern your time of exposing the article to the battery by the desired thickness of the plate. During the time it should be taken out and polished up as just directed about every ten minutes, or as often at least as there is an indication of a growing darkness on any part of its surface. When done, finish with the burnisher on prepared chalk and chamois skin, as best suits your taste and convenience.

In case the article to be plated is iron, steel, lead, pewter, or block tin, you must, after first cleansing with the lye and chalk, prepare it by applying with a soft brush—a camel's hair pencil is best suited—a solution made of the following articles in the proportion named: Nitric acid, half an ounce; muriatic acid, one-third of an ounce; sulphuric acid, one-ninth of an ounce; muriate of potash, one-seventh of an ounce; sulphate of iron, one-fourth of an ounce; sulphuric ether, one-fifth of an ounce, and as much sheet zinc as it will dissolve. This prepares a foundation, without which the plate would fail to take well, if at all.

To Make Gold Amalgam.—Eight parts of gold and one of mercury are formed into an amalgam for plating, by rendering the gold into thin plates, making it red hot and then putting it into the mercury while the latter is also heated to ebullition. The gold immediately disappears in combination with the mercury, after which the mixture may be turned into water to cool. It is then ready for use.

To Plate With Gold Amalgam.—Gold amalgam is chiefly used as a plating for silver, copper, or brass. The article to be plated is washed over with diluted nitric acid or potash lye and prepared chalk, to remove any tarnish or rust that might prevent the amalgam from adhering. After having been polished perfectly bright, the amalgam is applied as evenly as possible, usually with a fine scratch brush. It is then set upon a grate over a charcoal fire, or placed into an oven and heated to that degree at which mercury exhales. The gold, when the mercury has evaporated, presents a dull yellow color. Cover it with a coating of pulverized nitre and alum in equal parts, mixed to a paste with water, and heat again till *it* is thoroughly melted, then plunge into water. Burnish up with a steel or bloodstone burnisher.

To Make and Apply Gold Plating Solution.—Dissolve half an ounce of gold amalgam in one ounce of nitro-muriatic acid. Add two ounces of alcohol, and then, having brightened the article in the usual way, apply the solution with a soft brush. Rinse and dry in saw-dust, or with tissue paper, and polish up with chamois skin.

To Make and Apply Gold Plating Powders.—Prepare a chloride of gold the same as for plating with a battery. Add to it, when thoroughly washed out, cyanuret potassa in the proportion of two ounces to five pennyweights of gold. Pour in a pint of clean rain water, shake up well and then let stand till the chloride is dissolved. Add then one pound of prepared Spanish whiting and let evaporate in the open air till dry, after which put away in a tight vessel for use. To apply it you prepare the article in the usual way, and having made the powder into a paste with water, rub it upon the surface with a piece of chamois skin or cotton flannel.

An old mode of making a gold plating powder was to dip clean linen rags into solution prepared as in the second article preceding this, and having dried, to fire and burn them into ashes. The ashes formed the powder, and were to be applied as above.

To Make and Apply Silver Plating Solution.—Put together in a glass vessel one ounce nitrate of silver, two ounces cyanuret potassa, four ounces prepared Spanish whiting, and ten ounces pure rain water. Cleanse the article to be plated as per preceding directions, and apply with a soft brush. Finish with the chamois skin or burnisher.

To Make and Apply Silver Plating Powder.—Dissolve silver in nitric acid by the aid of heat; put some pieces of copper into the solution to precipitate the silver; wash the acid out in the usual way; then with fifteen grains of it mix two drachms of tartar, two drachms of table salt, and half a drachm of pulverized alum. Brighten the article to be plated with lye and prepared chalk, and rub on the mixture. When it has assumed a white appearance, expose to heat as in the case of plating with gold amalgam, then polish up with the burnisher or soft leather.

To Frost Watch Movments.—Sink that part of the article to be frosted for a short time in a compound of nitric acid, muriatic acid and table salt—one ounce of each. On removing from the acid, place it in a shallow vessel containing enough sour beer to merely cover it; then with a fine scratch brush scour thoroughly, letting it remain under the beer during the operation. Next wash off, first in pure water and then in alcohol. Gild or silver in accordance with any recipe in the chapter on plating.

To Enamel Gold and Silver.—Take half a pennyweight of silver, two pennyweights and a half of copper, three pennyweights and a half of lead, and two pennyweights and a half of muriate of ammonia. Melt together and pour into a crucible with twice as much pulverized sulphur; the crucible is then to be immediately covered that the sulphur may not take fire, and the mixture is to be calcined over a smelting fire until the superfluous sulphur is burned away. The compound is then to be coarsely pounded, and

with a solution of muriate of ammonia to be formed into a paste which is to be placed upon the article it is designed to enamel. The article must then be held over a spirit lamp till the compound upon it melts and flows. After this it may be smoothed and polished up in safety. This makes the black enamel now so much used on jewelry.

To Destroy the Effects of Acid on Clothes.—Dampen as soon as possible after exposure to the acid with spirits ammonia. It will destroy the effect immediately.

To Wash Silver Ware.—Never use a particle of soap on your silverware, as it dulls the lustre, giving the article more the appearance of pewter than silver. When it wants cleaning rub it with a piece of soft leather and prepared chalk, the latter made into a kind of paste with pure water, for the reason that water not pure might contain gritty particles.

To Cleanse Brushes.—The best method of cleansing watchmakers' and jewelers' brushes is to wash them out in strong soda water. When the backs are wood you must favor that part as much as possible, for, being glued, the water might injure them.

To Cut Glass Round or Oval Without a Diamond.—Scratch the glass around the shape you desire with the corner of a file or graver; then, having bent a piece of wire in the same shape, heat it red hot and lay it upon the scratch, sink the glass into cold water just deep enough for the water to come almost upon a level with its upper surface. It will rarely ever fail to break perfectly true.

To Re-Black Clock Hands.—Use asphaltum varnish. One coat will make old rusty hands look as good as new, and it dries in a few minutes.

Improved Wood Filing Composition. — Japan, ½ pt.; boiled linseed oil, ½ pt.; turpentine, ½ pt.; starch, 6 oz. Mix *well* together and apply to the wood. On walnut wood add a little burned umber, on cherry a little Venetian red, to the above mixture.

Planing Metals.—The first operation about planing is to oil your planer and find out if the bed is smooth. If it is not file off the rough places; then change the dogs to see if they will work well, and find out the movements of the planer. After doing this, bolt your work on to the bed, and if it is a long, thin piece, plane off a chip, then turn it over and finish the other side, taking two chips, the last of which should be very light. Great care should be taken in bolting the bed not to spring it. After finishing this side turn it to the other side, and take off a light cut to finish it.

Planing Perpendicularly.—In planing perpendicularly, it is necessary to swivel the bottom of the small head around, so it will stand about three-fourths of an inch inside of square, towards the piece you are to plane. This prevents breaking the tool when the bed runs back.

Gear Cutting.—In cutting gears, they are reckoned on a certain

number of teeth to the inch, measuring across the diameter to a certain line which is marked on the face or sides of the gear with a tool. This line is one-half the depth of the teeth from the outer diameter. That is, if the teeth of the gear are two-tenths of an inch deep, this line would be one-tenth of an inch from the edge, and is called the pitch line.

Depth of Teeth.—Every gear cut with a different number of teeth to the inch, should be cut of a depth to the pitch line, to correspond with the number of teeth to the inch. This is called proportion. Therefore, if you cut a gear eight to the inch, the depth to the pitch line should be one-eighth of an inch, and the whole depth of the tooth would be two-eighths. Again, if you cut a gear twelve to the inch, the depth to pitch line should be one-twelfth of an inch, and the whole depth of tooth two-twelfths. And again, if you cut a gear twenty to the inch, the depth to pitch line should be one-twentieth of an inch, while the whole depth should be two-twentieths, and so on *ad infinitum*.

Measuring to find the Number of Teeth.—To find the size a certain gear should be, for a certain number of teeth, is an easy matter if you study carefully these rules. If you want a gear with thirty-two teeth and eight to the inch, it should be four inches, measuring across the diameter to the pitch line, and the two-eighths outside of the pitch line would make it four inches and two-eighths. Again, if you want a gear with forty teeth, and ten to the inch, it should measure across the diameter to pitch line four inches, and the two-tenths outside the pitch line would make the whole diameter four inches and two-tenths. And again, if you want a gear with eighty teeth, and twenty to the inch, it should measure to the pitch line, across the diameter, four inches, and the two-twentieths outside the pitch line would make it four inches and two-twentieths, and these examples will form a rule for the measurement of all except bevel gears.

Bevel Gears.—These are turned a certain bevel to correspond with each other, according to the angle upon which the shafts driven by them are set. For instance, if two shafts are set upon an angle of ninety degrees, the surfaces of the faces of these gears will stand at an angle of forty-five degrees. To get the surface of these gears in turning them, put a straight edge across the face, then set your level on an angle of forty-five degrees, and try the face of the teeth by placing the level on a straight edge. After turning the face of the teeth, square the outer diameter by the face of the teeth: and to get the size to which you wish to cut, measure from the centre of the face of the teeth. Thus if a bevel gear is six inches in diameter, and the face of the teeth is one inch, you will measure from the centre of the face, and find it is five inches. On this line you calculate the number of teeth to the inch, and if you want a gear with twenty teeth, and ten to the inch, it should measure two inches across the face to the centre of the surface of the teeth; and if the face of the teeth were one inch in length, the diameter of the gear would be three inches, and the inside of the teeth would measure only one inch. Again if you want to cut a

gear with forty teeth, and ten to the inch, it would measure four inches to the centre of the teeth on the surface. And if the surface of the teeth were one inch long, the diameter of the gear would be five inches, while it would only measure three inches inside the teeth. These examples will form a rule for all bevel gear.

Draw-Filing and Finishing.—To draw-file a piece of work smoothly and quickly, it is best to first draw-file it with a medium fine file, and finish with a superfine file. After doing this, polish the work with dry emery paper, and then with emery paper and oil.

Lining Boxes with Babbitt Metal.—To line boxes properly, so as to insure their filling every time, it is necessary to heat the box nearly red hot, or at least hot enough to melt the metal. Then smoke the shaft where the metal is to be poured upon it. This insures its coming out of the box easily, after it is cold. After smoking the shaft, put it into the box or boxes, and draw some putty around the ends of them, for the purpose of stopping them, taking care not to press upon it, for if you do it will go into the box, and fill a place that ought to be filled with metal; and in the meantime your metal ought to be heated, and after you have poured it, let the box stand till it is nearly cold; drive out your shaft, and it is done.

Making Lining Metal.—Melt in a crucible one and a half pounds of copper, and while the copper is melting, melt in a ladle twenty-five pounds of tin, and three of antimony, nearly red hot, pour the two together, and stir until nearly cool. This makes the finest kind of lining metal.

Putting Machines Together.—In putting machines together no part should be finished except where it is necessary to make a fit, as it is sometimes the case that machinery is miscalculated, and by finishing it would be spoiled, while if it were not it might be saved by slight alterations in design. And again, in finishing certain parts before you get a machine together, you are unknowingly finishing parts not necessary to be finished, and making them of a shape anything but desirable. This rule, however, is not intended to apply to machinery being made to detail drawings.

To Drill a Hole where you have no Reamer.—It is sometimes necessary to drill a hole of an exact size to fit a certain shaft, and at the same time have it smooth without reaming it. This may be done, by first drilling a hole, a one-hundredth of an inch smaller than the size desired, and then making a drill the exact size and running it through to finish with. This last drill should have the corners of its lips rounded, like a reamer, and the hole should be finished without holding the drill with a rest.

Boring a Hole with a Boring Tool.—In boring a hole with a boring tool, it is usually necessary to drill the hole first, and too much care cannot be taken in finishing. An iron gauge should be made first; is usually made of a piece of sheet iron or wire. The hole should then be drilled smaller than the size desired, and then bored to the required size, and it is impossible to bore a hole perfect

without taking two or three light chips, mere scrapings with which to finish. Holes, in this way, may be bored as nicely as they can be reamed.

Squaring or Facing up Cast Iron Surfaces.—A round end tool is best for this. A rough chip should first be taken off, over the entire surface to be faced. Then speed your lathe up and taking a light chip, merely enough to take out the first tool marks, run over the entire surface again. In turning up surfaces it is always best to begin at the centre and feed out, as the tool cuts freer and will wear twice as long.

Boring Holes with Boring Arbor.—A boring arbor is a shaft with a steel set in it, for the purpose of boring holes of great length, and is designed to be used in a lathe. In doing this properly, you must first see if your lathe is set straight. If not, adjust it; having done this, put the piece of work to be bored in the carriage of your lathe, pass your arbor through the hole to be bored, and put it on the centres of your lathe. Having done this, adjust your work true to the position desired by measuring from the point of the tool, continually turning round the arbor from side to side of the piece to be bored, while you are bolting it to the carriage, and measure until it is perfectly true. Having done this, bore the hole, and take for the last chip only a hundredth of an inch. This makes a true and smooth hole. It is impossible to make a hole true with any kind of a tool when you are cutting a large chip, for the tool springs so that no dependence can be placed upon it.

To make a Boring Arbor and Tool that will not Chatter.—Boring tools, when used in small arbors, are always liable to chatter and make a rough hole. To prevent this, the tool should be turned in a lathe, while in its position in the arbor, upon the circle of the size of the hole to be bored, and the bearing lengthwise of the arbor should be only as wide as the feed of the lathe; for if the bearing of the tool is on the face, the more it will chatter.

CEMENTS.

[See other pages also.]

Rust Joint.—QUICK SETTING.—1 lb. sal ammoniac in powder, 2 lbs. of flour of sulphur, 80 lbs. iron borings. Made to a paste with water. SLOW SETTING.—2 lbs. sal ammoniac, 1 lb. of sulphur, 200 lbs. iron borings. This latter cement is best if the joint is not required for immediate use.

For Steam Boilers, Steam Pipes, Etc.—SOFT.—Red or white lead in oil, 4 parts; iron borings, 2 to 3 parts. HARD.—Iron borings and salt water, and a small quantity of sal ammoniac with fresh water.

Maltha, or Greek Mastic.—Lime and sand mixed in the manner of mortar, and made into a proper consistency with milk or size without water.

For China.—Curd of milk, dried and powdered, 10 oz.; quicklime, 1 oz.; camphor, 2 drachms. Mix, and keep in closely stopped bottles. When used, a portion is to be mixed with a little water into a paste.

For Earthen and Glassware.—Heat the article to be mended a little above 212°, then apply a thin coating of gum shellac upon both surfaces of the broken vessel. Or, dissolve gum shellac in alcohol, apply the solution, and bind the parts firmly together until the cement is dry.

Holes in Casting.—Sulphur in powder, 1 part; sal ammoniac, 2 parts; powdered iron turnings, 80 parts. Make into a thick paste. The ingredients composing this cement should be kept separate, and not mixed until required for use.

For Marble.—Plaster of Pasis, in a saturated solution of alum, baked in an oven, and reduced to powder. Mixed with water. It may be mixed with various colors.

For Marble Workers and Coppersmiths. — White of egg, mixed with finely sifted quicklime, will unite objects which are not submitted to moisture.

Transparent for Glass.—India rubber, 1 part in 64 of chloroform; add gum mastic in powder, 16 to 24 parts. Digest for two days with frequent shaking.

To Mend Iron Ware.—Sulphur, 2 parts; fine black lead, 1 part. Put the sulphur in an iron pan, over a fire, until it melts, then add the lead; stir well; then pour out. When cool, break into small pieces. A snfficient quantity of this compound being placed upon the crack of the ware to be mended, can be soldered by an iron.

For Cisterns and Water Casks.—Melted glue, 8 parts; linseed oil, 4 parts; boiled into a varnish with litharge. This cement hardens in about 48 hours, and renders the joints of wooden cisterns and casks air and water tight.

Hydraulic Cement Paint.—Hydraulic cement mixed with oil forms an incombustible and waterproof paint for roofs of buildings, out-houses, walls, etc.

Entomologists' Cement.—Thick mastic varnish and isinglass size, equal parts.

BROWNING.

[See other pages also.]

Browning, or Bronzing Liquid. — Sulphate of copper, 1 oz.; sweet spirit of nitre, 1 oz.; water, 1 pint. Mix. In a few days it will be fit for use.

Browning for Gun Barrels.—Tinct. of mur. of iron, 1 oz.; nitric ether, 1 oz.; sulphate of copper, 4 scruples; rain water, 1 pint. If the process is to be hurried, add 2 or 3 grains of oxymuriate of mercury. When the barrel is finished, let it remain a short time in lime water, to neutralize any acid which may have penetrated; then rub it well with an iron wire scratch brush.

Hardening Compound used in Damascus Sword Blades.—The blade is covered with a paste formed of equal parts of barilla, powdered egg-shells, borax, common salt, and crude soda; heated to a moderate red heat, and just as the red is turning to a black heat, quench it in spring water.

LACKERS.

For Small Arms, or Waterproof Paper.—Beeswax, 13 lbs.; spirits of turpentine, 13 gallons; boiled linseed oil, 1 gallon. All the ingredients should be pure and of the best quality. Heat them together, in a copper or earthen vessel over a gentle fire, in a water-bath, until they are well mixed.

For Bright Iron Work.—Linseed oil, boiled, 80.5; litharge, 5.5; white lead, in oil, 11.25; resin, pulverized, 2.75. Add the litharge to the oil; let it simmer over a slow fire 3 hours; strain it, and add the resin and white lead; keep it gently warmed, and stir it until the resin is dissolved.

INKS.

Indelible, for Marking Linen, Etc.—1. Juice of sloes, 1 pint; gum, ½ an ounce. This requires no "preparation" or mordant, and is very durable. 2. Nitrate of silver, 1 part; water, 6 parts; gum, 1 part. Dissolve. MARKING.—Lunar caustic, 2 parts; sap green and gum arabic, each 1 part; dissolve with distilled water. THE "PREPARATION."—Soda, 1 ounce; water, 1 pint; sap green, ½ drachm. Dissolve, and wet the article to be marked, then dry and apply the ink.

PERPETUAL, FOR TOMB STONES, MARBLE, ETC.—Pitch, 11 parts; lampblack, 1 part; turpentine sufficient. Warm and stir.

COPYING INK.—Add 1 oz. of sugar to a pint of ordinary ink.

GLUES.

[See other pages also.]

For Parchment.—Parchment shavings, 1 lb.; water, 6 quarts. Boil until dissolved, then strain and evaporate slowly to the proper consistence.

Rice Glue, or Japanese Cement.—Rice flour; water, sufficient quantity. Mix together cold, then boil, stirring it all the time.

Liquid.—Glue, water, and vinegar, each 2 parts. Dissolve in a water-bath, then add alcohol, 1 part. Or, cologne or strong glue, 2.2 lbs.; water, 1 quart; dissolved over a gentle heat; add nitric acid 36°, 7 oz., in small quantities. Remove from the fire and cool. Or, white glue, 16 oz.; white lead, dry, 4 oz.; rain water, 2 pints. Add alcohol, 4 oz., and continue the heat for a few minutes.

Marine.—Dissolve India-rubber, 4 parts, in 34 parts of coal-tar naphtha; add powdered shellac, 64 parts. While the mixture is hot it is poured upon metal plates in sheets. When required for use, it is heated, and then applied with a brush. Or, 1 part India-rubber, 12 parts of coal-tar; heat gently, mix, and add 20 parts of powdered shellac. Pour out to cool. When used, heat to about 250°. Or, glue, 12 parts; water, sufficient to dissolve; and yellow resin, 3 parts; and, when melted, add turpentine, 4 parts. Mix thoroughly together.

STRONG GLUE.—Add powdered chalk to common glue.

GUM MUCILAGE.—A little oil of cloves poured into a bottle containing gum mucilage, prevents it from becoming sour.

Glue to Resist Moisture.—5 parts glue, 4 parts resin, 2 parts red ochre, mixed with the least practicable quantity of water. Or, 4 parts of glue, 1 part of boiled oil by weight, 1 part oxide of iron. Or, 1 lb. of glue melted in 2 quarts of skimmed milk.

VARNISHES.

[See other pages also.]

Waterproof.—Flour of sulphur, 1 lb.; Linseed-oil, 1 gal.; boil them until they are thoroughly combined. This forms a good varnish for waterproof textile fabrics. Another is made of oxide of lead, 4 lbs.; lamp-black, 2 lbs.; sulphur, 5 oz.; and India-rubber dissolved in turpentine, 10 lbs. Boil together until they are thoroughly combined.

To Adhere Engravings or Lithographs upon Wood.—Sandarach, 250 parts; mastic in tears, 64; resin, 125; Venice turpentine, 250; and alcohol, 1000 parts by measure.

For Harness.—India-rubber, ½ lb.; spirits of turpentine, 1 gal.; dissolve into a jelly; then take hot linseed oil, equal parts with the mass, and incorporate them well over a slow fire.

For Fastening Leather on Top Rollers.—Gum Arabic, 2¾ oz., dissolved in water, and a like volume of isinglass dissolved in water.

To Preserve Glass from the Rays of the Sun.—Reduce a quantity of gum tragacanth to fine powder, and let it dissolve for 24 hours in white of eggs well beat up.

For Water-Color Drawings.—Canada balsam, 1 part; oil of turpentine, 2 parts, mixed. Size the drawing before applying the varnish.

For Objects of Natural History, for Shells, Fish, &c.—Mucilage of gum tragacanth and mucilage of gum arabic, each 1 oz. Mix, and add spirit with corrosive sublimate, so as to precipitate the more stringy part of the gum.

For Articles of Iron and Steel.—Clear grains of mastic, 10 parts; camphor, 5 parts; sandarach, 15 parts; and elemi, 5 parts. Dissolve in a sufficient quantity of alcohol, and apply without heat. This varnish will retain its transparancy, and the metallic brilliancy of the article will not be obscured.

For Gun Barrels, after Browning.—Shellac, 1 oz.; Dragon's blood, ¼ oz.; rectified spirit, 1 quart. Dissolve and filter.

Black.—Heat to boiling, 10 parts of linseed oil varnish with burnt umber, 2 parts, and powdered asphaltum, 1 part. When cooled, dilute with spirits of turpentine as required.

Balloon.—Melt India-rubber in small pieces with its weight of boiled linseed oil. Thin with oil of turpentine.

Transfer.—Alcohol, 5 oz.; pure Venice turpentine, 4 oz.; mastic, 1 oz.

To Clean Varnish.—Mix a lye of potash, or soda, with a little powdered chalk.

Composition for Rendering Canvas Waterproof and Pliable.—Yellow soap, 1 lb., boiled in 6 pints of water, add, while hot, to 112 lbs. of paint.

Good Painting requires 4 or 5 coats; but usually only 4 are used in principal rooms; and 3 in inferior ones. Each coat must be allowed to dry perfectly before the next one is put on. One lb. of the keg paint will, after being thinned, cover about 2 sq. yds. of first coat; 3 yds. of second; and 4 yds. of each subsequent coat; or 1 sq. yd. of 3 coats will require in all, 1·08 lbs.; of 4 coats, 1⅓ lbs.; of 5 coats, 1·58 lbs. The reason why the first coats require so much more than the subsequent ones, is that the bare surface of the wood absorbs it more.

Painting of Brick Work.—A square yard of new brick wall requires for the first coat of paint in oil, ¾ lb.; and for the second, ·3; and for the third, ·4.

MISCELLANEOUS.

To Clean Marble.—Chalk, powdered, and pumice-stone, each 1 part; soda, 2 parts. Mix with water. Wash the spots, then clean and wash off with soap and water.

To Extract Grease from Stone or Marble.—Soft soap, 1 part; Fuller's earth, 2 parts; potash, 1 part. Mix with boiling water. Lay it upon the spots, and let it remain for a few hours.

Paint for Window Glass.—Chrome green, ¼ oz.; sugar of lead, 1 lb.; ground fine, in sufficient linseed oil to moisten it. Mix to the consistency of cream, and apply with a soft brush. The glass should be well cleaned before the paint is applied. The above quantity is sufficient for about 200 feet of glass.

Durable Paste.—Make common flour paste rather thick (by mixing some flour with a little *cold* water until it is of uniform consistency, and then stir it well while *boiling* water is being added to it;) add a little brown sugar and corrosive sublimate, which will prevent fermentation, and a few drops of oil of lavender, which will prevent it becoming mouldy. When this paste dries, it may be used again by dissolving it in water. It will keep for two or three years in a covered vessel.

Dubbing.—Resin, 2 lbs.; tallow, 1 lb.; train-oil, 1 gallon.

Blacking for Harness.—Bees' wax, ½ lb.; ivory black, 2 oz.; spirits of turpentine, 1 oz.; Prussian blue ground in oil, 1 oz.; copal varnish, ¼ oz. Melt the wax and stir it into the other ingredients before the mixture is quite cold; make it into balls. Rub a little upon a brush, and apply it upon the harness, then polish lightly with silk.

To Prevent Iron from Rusting.—Warm it; then rub with white wax; put it again to the fire until the wax has pervaded the entire surface. Or, immerse tools or bright work in boiled linseed oil and allow it to dry upon them.

Paper for Draughtsmen, &c.—Powdered tragacanth, 1 part; water, 10 parts; dissolve, and strain through clean gauze, then lay it smoothly upon the paper, previously stretched upon a board. This paper will take either oil or water-colors.

To Remove Old Ironmould.—Remoisten the part stained with ink, remove this by the use of muriatic acid diluted by 5 or 6 times its weight of water, when the old and new stain will be removed.

Pastiles for Fumigating.—Gum arabic, 2 oz.; charcoal powder, 5 oz.; cascarilla bark, powdered ¾ oz.; saltpetre, ¼ drachm. Mix together with water, and make into shape.

For Writing Upon Zinc Labels—Horticultural.—Dissolve 100 gr. of chloride of platinum in a pint of water; add a little mucilage and lamp-black. Or, sal-ammoniac, 1 dr; verdigris, 1 dr.; lamp-back, ½ dr.; water, 10 drs. Mix.

Booth's Grease for Railway Axles.—Water, 1 gall,; clean tallow, 3 lbs.; palm oil, 6 lbs.; common soda, ½ lb.; or, tallow, 8 lbs.; palm oil, 10 lbs. To be heated to about 212°, and to be well stirred until it cools to 70°.

Anti-friction Grease.—100 lbs. tallow, 70 lbs. palm oil. Boiled together, and when cooled to 80°, strain through a sieve, and mix with 28 lbs. of Soda and 1½ gals. of water. For winter, take 25 lbs. more oil in place of the tallow. Or black lead, 1 part; lard, 4 parts.

Liard.—50 parts of finest rape oil and 1 part of caoutchouc, cut small. Apply heat until it is nearly all dissolved.

Stains.—To remove—Stains of *Iodine* are removed by rectified spirit. *Ink* stains by oxalic or superoxalate of potash. *Ironmoulds* by the same; but if obstinate, moisten them with ink, then remove them in the usual way.

Red spots upon black cloth from acids are removed by spirts of hartshorn, or other solutions of ammonia.

Stains of Marking-ink, or nitrate of Silver.—Wet the stain with fresh solution of cloride of lime, and after 10 or 15 minutes, if the marks have become white, dip the part in solution of ammonia or of hyposulphite of soda. In a few minutes wash with clean water. Or stretch the stained linen over a basin of hot water, and wet the mark with tincture of iodine.

Preservative Paste for Objects of Natural History.—White arsenic, 1 lb.; powdered hellebore, 2 lbs.

Paste for Cleaning Metals.—Oxalic acid, 1 part; rottenstone, 6 parts. Mix with equal parts of train oil and spirits of turpentine.

Watchmaker's Oil, which never Corrodes or Thickens.—Place coils of thin sheet lead in a bottle with olive oil. Expose it to the sun for a few weeks, and pour off the clear oil.

Blacking, Without Polishing.—Molasses, 4 oz.; lamp-black, ½ oz.; yeast, a tablespoonful; eggs, 2; olive oil, a teaspoonful; turpentine, a teaspoonful. Mix well. To be applied with a sponge, without brushing.

To Preserve Sails.—Slacked lime, 2 bushels. Draw off the lime water, and mix it with 120 gallons water, and with blue vitriol, ¼ lb.

Whitewash.—For outside exposure, slack lime, ½ a bushel, in a barrel; add common salt, 1 lb.; sulphate of zinc, ½ lb.; and sweet milk, 1 gal.

To Preserve Woodwork..—Boiled oil and finely powdered charcoal, each 1 part; mix to the consistence of paint. Lay on 2 or 3 coats with it. This composition is well adapted for casks, water-spouts, &c.

To Polish Wood.—Rub surface with pumice stone and water

until the rising of the grain is removed. Then, with powdered tripoli and boiled linseed oil, polish to a bright surface.

To Clean Brass Ornaments.—Brass ornaments that have not been gilt or lackered may be cleaned, and a very brilliant color given to them, by washing them in alum boiled in strong lye, in the proportion of an ounce to a pint, and afterward rubbing them with strong tripoli.

Adhesive Cement for Fractures of all Kinds.—White lead ground with linseed oil varnish, and kept out of contact with the air. It requires a few weeks to harden. When stone or iron are to be cemented together, use a compound of equal parts of sulphur and pitch.

ADDENDA TO PART II.

ALLOYS.

Aluminium and its Alloys.—Of all the metals, properly so called, the compounds of which make up the crust of the earth, aluminium is the most abundant. It is evident, therefore, that there can be no difficulty in obtaining material to work upon. Now, taking ordinary clay as an instance, it can be readily shown that in every cubic yard there is at least 800 lbs. of aluminium, the lowest recorded price of which is $2.00 a pound. But the only process by which any quantity worth speaking about of the pure metal aluminium—in contradistinction to its alloys—has ever been extracted is the process of Deville, established about the year 1854. The main features of the process and the sequence of operations have remained unchanged. In the Cowles and other electric processes the aluminium is always produced as an alloy, with either copper or iron. The manufacture of the pure metal on a commercial scale does not appear to have been successful so far, and it is probable that the large demand for the alloys has prevented proper attention being given to this branch of the subject.

The mode of electrically producing aluminium alloys invented by the Cowles Brothers, of Cleveland, Ohio, is as follows: They construct a rectangular box of fire-resisting material, lined with a mixture of fine charcoal and lime. It has a removable cover, which is perforated with openings to allow the escape of gases evolved. In the sides of this furnace the electrodes—two plates of gas carbon—are let in, by means of which the current of a powerful dynamo-electric machine is introduced. The charge consists of a mixture of the coarsely crushed ore and coke fragments. The essential feature of the process consists, therefore, in employing in the furnace a substance like carbon, whose great resistance to the passage of the current causes the production of a prodigiously high temperature, and which, at the same time, is capable of exercising a powerful reducing action on the ore. With such an arrangement of apparatus and the use of a powerful electric current, the inventors have succeeded in reducing aluminium from corundum, and have greatly cheapened the cost of aluminium bronzes and brasses.

The Herault process for the production of aluminium, though elec-

trical, differs from that of Messrs. Cowles Brothers in being, in the main, electrolytic. Works have been erected at Lauffen-Neuhausen, Switzerland, by the Swiss Metallurgical Company, for carrying out the process on a commercial scale. An electrical plant, capable of producing daily about 6 cwt. of aluminium, or its equivalent in a 10 per cent. aluminium bronze, is in use. In carrying out the process the electric current is employed to fuse the metal with which the aluminium is to be alloyed, and to separate the aluminium by electrolysis of alumina in a molten state. The current is produced by two dynamos, each of 6,000 ampères and 20 volts, their magnetic field being excited by a separate dynamo, the combination being driven by a Jonval turbine of 300 horse-power. The metal, copper for the production of aluminium bronze, is introduced in a divided state into a crucible formed of conducting carbon, suitably strengthened by external casing of metal; this crucible forming the negative pole of the electrolyzing bath, the positive pole being composed of a bundle of carbon plates. After the copper is fused, alumina is introduced into the crucible, where it is fused and electrolyzed, the oxygen passing off at the positive pole and the aluminium at the negative, and there uniting with the fused copper. The process is thus continuous, the fused alloy being drawn off by means of a plugged hole at the bottom of the crucible, and fresh copper and alumina being introduced by suitable openings in the cover as required. The current passing through the crucible is from 12,000 to 13,000 ampères, with a difference of potential between the electrodes of about 12 to 15 volts.

F. Lauterborn has patented in Germany the following process of preparing aluminium from aluminium sulphate by means of antimony and coal at a high temperature: The crude aluminium sulphate is freed from water by heating in crucibles or upon a hearth, and the resulting porous mass pulverized; 100 parts of aluminium sulphate, 50 of coal, and 72 of antimony are mixed, and, after adding fluor spar, sodium carbonate or sodium sulphide for the formation of slag, the mixture is heated in a crucible or furnace until it melts, and is for some time kept in flux by a blowing engine. The specifically very heavy sulphide of antimony formed settles on the bottom of the crucible, but is converted into slag by the addition of sodium. The antimony is regained as regulus from the sulphide of antimony by means of iron in the known manner.

The greatest value of aluminium, perhaps, is in the wonderful alloys it is capable of producing. These are very numerous and always satisfactory alloyed with wrought-iron and steel, giving certain properties that enable those metals to be cast successfully and without blow-holes; with copper, the beautiful gold bronze; with silver, the *tiers agent* of the French; and with zinc, nickel, tin, and manganese it forms valuable and characteristic alloys, giving to them qualities of great tensile strength, immunity from oxidation, and other advantages.

Aluminium-Bronze.—The alloys of aluminium with copper show very different properties according to the quantity of aluminium they contain. Alloys containing but little copper cannot be used for industrial purposes. With 60 to 70 per cent. of aluminium they are brittle, glass-hard, and beautifully crystalline. With 50 per cent. the alloy is quite soft, but under 30 per cent. of aluminium the hardness returns.

The usual alloys are those of 1, 2, 5, and 10 per cent. The 5 per cent. bronze is golden in color, polishes well, casts beautifully, is very

malleable cold or hot, and has great strength, especially after hammering. The 7.5 per cent. bronze is to be recommended as superior to the 5 per cent. bronze. It has a peculiar greenish-gold color, which makes it very suitable for decoration. All these good qualities are possessed by the 10 per cent. bronze. It is bright golden, keeps its polish in the air, may be easily engraved, shows an elasticity much greater than steel, and can be soldered with hard solder. When it is made by a simple mixing of ingredients it is brittle, and does not acquire its best qualities until after having been recast several times. After three or four meltings it reaches a maximum, at which point it may be melted several times without sensible change. It gives good castings of all sizes, and runs in sand moulds very uniformly. Thin castings come out very sharp, but if a casting is thin and suddenly thickens, small off-shoots must be made at the thick place, into which the metal can run and then soak back into the casting as it cools and shrinks, thus avoiding cavities by shrinkage at the thick part. Its specific gravity is 7.68, about that of soft iron. Its strength when hammered is equal to the best steel. It may be forged at about the same heat as cast-steel, and then hammered until it is almost cold without breaking or ripping. Tempering makes it soft and malleable. It does not foul a file and may be drawn into wire. Any part of a machine which is usually made of steel can be replaced by this bronze.

The melting-point of aluminium-bronze varies slightly with the content of aluminium, the higher grades melting at a somewhat lower temperature than the lower. The 10 per cent. bronze melts at about 1700° F., a little higher than ordinary bronze or brass.

Aluminium-bronze shrinks about twice as much as brass, and hence due allowance has to be made for this in the mould and pattern. As the metal solidifies rapidly, it is necessary to pour it quickly and to make the gates amply large, so that there will be no "freezing" in the "gates" before the casting is properly fed. To obviate the shrinkage as much as possible, the metal is allowed to enter the mould at a temperature not higher than will admit of it running freely. When there is a heavy mass of metal in the shape of an envelope surrounding a core, the contraction upon solidification will cause the metal to split unless the core is made to yield equally with the contraction. Baked sand moulds are preferable to green sand, except for small castings.

One of the chief difficulties met with in the casting of aluminium-bronze is to avoid oxidation in transferring the metal from the crucible or ladle to the mould. If any of the film of oxide which floats on the surface should get into the casting during the pouring, it will appear there like so much dirt, and is apt to cause trouble. The ordinary "skim-gate" will prevent this in the case of small castings, but with large masses the metal is first poured into a receiver, which is connected with and is part of the "pouring-gate," but is prevented from entering the mould by means of a plug which closes up the mouth of the "gate." To illustrate this more clearly, imagine the pouring-gate shaped like a funnel, into which the metal is first poured. It is prevented from running into the mould by the plug already mentioned. As soon as the dirt has risen to the top the plug is withdrawn, and consequently nothing but the clear metal at the bottom enters the mould. For casting over 50 lbs., the metal is poured from a large ladle through a hole in the bottom. Ample facilities should be made for the escape of gases.

Both aluminium and copper volatilize only at extremely high tem-

peratures, and consequently aluminium-bronze can be remelted without any appreciable change in the strength or quality of the metal whatever.

Aluminium-bronze forges similarly to the best Swedish iron, but at a much lower temperature. It works best at a cherry-red; if this is much exceeded, the metal becomes hot-short, and is easily crushed. The temperature for rolling is a bright-red heat; and it is a curious fact that, if the metal were forged at the temperature it is rolled, it would be crushed to pieces. If the temperature in the ordinary muffle in which it is heated be allowed to rise too high, the bronze will frequently fall apart by its own weight. When in the rolls it acts very much like yellow Muntz metal. As it loses its heat much more rapidly than copper or iron, it has to be annealed frequently between rollings.

Aluminium-Brass.—The addition of a few per cent. of aluminium to common brass greatly increases its tenacity and resistance to corrosion. Alloys containing copper, zinc, and aluminium between the following limits,

Copper	67 to 71 per cent.
Zinc	27½ " 30 " "
Aluminium	1¼ " 3 " "

and combined in different proportions, give tenacities from a little above 30,000 to over 65,000 lbs. per square inch. Alloys with much less copper and more zinc—55.8 to 57 per cent. copper and 42 to 43 per cent. zinc—approach nearer 70,000 lbs., and a specimen composed of copper 67.4 per cent., zinc 26.8, and aluminium 5.8, broke at over 95,000 lbs. tenacity per square inch.

Test of Aluminium-Bronze and Aluminium-Brass.—At Watertown Arsenal, Mass., a test ordered by the government was recently made, to determine what is the strongest metal to use for the screw-propellers of war-ships. The result was as follows:

Government Gun Bronze.

	Elastic limit.	Per cent. Elongation.	Pounds tensile strength per square in.
Copper 88, tin 10, zinc 2 per cent.	9,000	1.5	18,000
Copper 88, tin 10, zinc 2 per cent.	10,000	2.	18,000
Copper 88, tin 10, zinc 2 per cent.	13,000	3.	20,000
Copper 88, tin 10, zinc 2 per cent.	11,000	5.	22,500
Copper 88, tin 10, zinc 2 per cent.	13,000	1.5	23,000
Copper 88, tin 10, zinc 2 per cent.	10,000	3.5	19,000

Aluminium Bronze and Brass.

	Pounds elastic limits.	Per cent. Elongation.	Pounds tensile strength per square in.
Bronze composition—			
Copper and 8 per cent. Al & Si..........	19,000	23.7	58,500
Copper and 10 per cent. Al & Si.........	33,000	3.2	68,000
Copper and 8½ per cent. Al & Si.........	18,000	26.	61,000
Copper and 7½ per cent. Al & Si.........	19,000	9.3	52,000
Copper and 7 per cent. Al & Si..........	17,000	11.9	46,000
Copper and 8¾ per cent. Al & Si.........	24,000	13.3	66,500
Copper and 9 per cent. Al & Si..........	28,000	4.5	66,000
Copper and 10¼ per cent. Al & Si........	33,000	3.6	72,500
Brass Composition—			
Copper and 3⅓ al, 33⅓ per cent. Zn......	55,000	1.6	70,000
Copper and 3⅓ al, 33⅓ per cent. Zn......	65,000	2.5	82,500

All bars were 22 inches in length by 1⅛ inches in diameter, and 10 inches or 15 inches between elongation marks. It was conceded by all metal experts present that no bars of this size, even of steel castings, had ever shown anything like the combined strength, toughness, and high elasticity exhibited by those of aluminium-bronze and brass.

Aluminium-Bronze and Nickel Alloys.—A number of remarkable and useful alloys are made by mixing aluminium-bronzes with nickel in various proportions. These compositions are said to be very ductile, and to have a tenacity of from 75,000 to over 100,000 lbs. per square inch, with about 30 per cent. elongation. An alloy of a similar nature made by the "Webster Crown Metal Company," England, gives results ranging from 82,000 to over 100,000.

According to J. Webster, for preparing the bronze two alloys are used, which are designated as aluminium alloy (A) and nickel alloy (B.) A consists of 15 parts of aluminium and 85 of tin, and B of 17 parts of nickel, 17 of copper and 66 of tin. The metals are melted together in the usual manner with the use of a flux under a cover of common salt and chloride of potash. The two alloys are then melted together with copper. It has been found that the bronze is the harder and better, the more it contains of the two alloys and *vice versa*. The following is given as the best proportion: Copper 88 parts and 8 parts of each of A and B. When the copper is melted the alloys are added and then melted, being stirred with a wooden or clay rod (an iron rod must not be used under any condition) until the mass is homogeneous, which is recognized by a test-ingot. A second quality of aluminium-bronze which is cheaper than the preceding is composed of 92 parts of copper and 4 parts each of the alloys A and B.

Alloy of Aluminium and Gold.—This alloy, which is also known

as Nürnberg gold, is frequently used in the manufacture of cheap gold-ware, it being well adapted for the purpose as its color exactly resembles that of pure gold and remains unchanged in the air. The composition of most articles of Nürnberg gold is according to the following composition: Copper 90 parts, gold 2.5, aluminium 7.5.

Alloys of Aluminium and Silver.—Aluminium and silver form beautiful white alloys considerably harder than pure aluminium and taking a very high polish. These alloys have the advantage over copper alloys of being unchangeable on exposure to the air and retaining their white color. It has, therefore, been proposed to alloy coins with aluminium instead of copper, which would render them much more durable, but the results of experiments on a large scale were not satisfactory.

The alloys of aluminium and silver show very varying physical properties according to the content of aluminium. An alloy consisting of aluminium 100 parts and silver 5 differs but little from pure aluminium, but is considerably harder and takes a beautiful polish. An alloy of aluminium 169 parts and silver 5 possesses considerable elasticity, and is recommended for fine watch springs and dessert knives. An alloy of equal parts of aluminium and silver shows a hardness equal to that of bronze.

Tiers Argent (*One-third Silver*).—This alloy is chiefly prepared in Paris factories for the manufacture of various utensils, and as indicated by its name consists of silver 33.33 parts and aluminium 66.66. The advantage of this alloy over silver consists in the lower price and greater hardness; it is also stamped and engraved with greater ease than the alloys of copper and silver. It is especially suitable for nautical instruments, as it combines lightness with great resistance to the weather.

Alloy of Aluminium and Tin.—An alloy, the use of which it is claimed overcomes the difficulties of working and welding aluminium, is formed by melting together 100 parts of aluminium with 10 of tin. The alloy is whiter than aluminium and but little heavier, its specific gravity being 2.85. By most substances it is less attacked than pure aluminium, and it can be welded and soldered like brass without any special preparation.

Alloys of Aluminium and Iron.—Ostberg, a Swedish inventor, has devised an ingenious process of making castings (clean and sharp) of wrought iron, or, as they are called, mitis castings, by taking advantage of the observation which he made that the addition of an extremely small quantity of aluminium to wrought iron, kept at a white heat in a crucible, forms a combination which has a much lower fusing point than wrought iron.

In making mitis castings a very small quantity, about $\frac{5}{1000}$ to 1 per cent. of aluminium in the form of a 7 to 8 per cent. aluminium alloy of cast iron is added to the charge (about 60 lbs.) of wrought iron in the crucible the moment this has been melted. The fusing point is at once lowered some 500° F., and the charge, now an alloy of aluminium and iron, becomes extremely fluid and can be cast in the finest moulds, while the great difference between its temperature and its fusing point gives all the time necessary for manipulating it without danger of its

solidifying. The extreme fluidity of the charge allows the ready escape of the gases, which otherwise would make a porous casting, and the result is a remarkably fine, solid and tough casting of wrought iron.

These mitis castings are said to be from 30 to 50 per cent. stronger than the iron from which they are made, but though aluminium undoubtedly greatly increases the strength of most of the metals with which it alloys, it is not credited with the increase in strength in this case, for it is said that after hammering the mitis metal loses its increase in strength and returns to the fibrous appearance and to the strength of the original iron.

Brazing Aluminium-bronze.—Aluminium-bronze will braze as well as any other metal, using one-quarter brass solder (zinc 50 per cent., copper 50 per cent.) and three-quarters borax.

Soldering Aluminium-bronze.—To solder aluminium-bronze with ordinary soft (pewter) solder: Cleanse well the parts to be joined free from dirt and grease. Then place the parts to be soldered in a strong solution of sulphate of copper, and place in the bath a rod of soft iron touching the parts to be joined. After a while a copper-like surface will be seen on the metal. Remove from bath, rinse quite clean and brighten the surfaces. These surfaces can then be tinned by using a fluid consisting of zinc dissolved in hydrochloric acid in the ordinary way with common soft solder.

Aluminium-bronze for jewelry may be soldered by using the following composition:

Hard Solder for 10 *per cent. Aluminium-bronze.* Gold, 88.88 per cent.; silver, 4.68; copper, 6.44.

Middling Hard Solder for 10 *per cent. Aluminium-bronze.* Gold, 54.40 per cent.; silver, 27.60; copper, 18.

Soft Solder for Aluminium-bronze. Brass (copper, 70 per cent.; tin, 30), 14.30 per cent.; gold, 14.30; silver, 57.10; copper, 14.30.

Phosphor-bronze.—Phosphorus is the most effective addition for obtaining hard bronzes free from oxides. The content of phosphorus is imparted to the bronze by an addition of cupric phosphide or phosphide of tin, both these phosphor-metals being sometimes used at the same time.

Cupric phosphide is prepared by heating a mixture of 4 parts of super-phosphate of lime, 2 parts of granulated copper and 1 part of finely pulverized coal in a crucible at not too high a temperature. The melted cupric phosphide which contains 14 per cent. of phosphorus separates on the bottom of the crucible.

According to another method cupric phosphide is prepared by adding phosphorus to copper-sulphide solution and boiling, adding sulphur as the sulphide is precipitated. The precipitate is carefully dried, melted and cast into ingots. When of good quality and in proper condition it is quite black.

Phosphide of tin is prepared as follows: Place a bar of zinc in an aqueous solution of chloride of tin, collect the sponge-like tin separated and bring it moist into a crucible, upon the bottom of which sticks of phosphorus have been placed. Press the tin tightly into the crucible and expose it to a gentle heat. Continue the heating until flames of burning phosphorus are no longer observed on the crucible. After the

operation is finished a coarsely-crystalline mass of a tin-white color consisting of pure phosphide of tin is found upon the bottom of the crucible.

Phosphor-bronze is prepared by melting the alloy to be converted into it in the usual manner, and adding small pieces of cupric phosphide and phosphide of tin

The properties of correctly prepared phosphor-bronze are as follows: Its melting point is nearly the same as that of ordinary bronze. In cooling it shows, however, the phenomenon of passing directly from the liquid into the solid state without first becoming thickly fluid. In a melted state it retains a perfectly bright surface, while that of ordinary bronze is always covered with a thin film of oxide.

If phosphor-bronze be subjected to continued melting no loss of tin takes place, but the content of phosphorus decreases slightly.

The chief properties of phosphor-bronze are its extraordinary tenacity and strength; in a cold state it can be stretched, rolled and hammered. Its strength is double that of the best ordinary bronze. It is especially used for articles which are to show great strength and power of resisting external influences; for instance, the action of sea water.

Bronze with a content of tin of about 4 per cent. is especially suitable for the manufacture of sheet-metal; with up to 5 per cent. of tin it can be used in a forged state for gun-barrels and ordnance.

Bronzes with a content of tin between 7 and 10 per cent. have the greatest hardness and are especially adapted for axle-bearings, cylinders for steam fire-engines, cogwheels and generally for parts of machines requiring great strength and hardness. Phosphor-bronze acquires by exposure to the air for a short time a beautiful, tightly adhering patina and can therefore be suitably used for works of art. According to the purpose for which the bronze is to be used, the addition of phosphorus varies, but the following five sorts are considered to answer all requirements:

0. Ordinary phosphor-bronze of 2 per cent. of phosphorus.
1. Good phosphor-bronze of 2½ per cent. of phosphorus.

These two numbers are in all cases superior to ordinary bronze and steel.

2. Superior phosphor-bronze of 3 per cent. of phosphorus.
3. Extra phosphor-bronze of 3½ per cent. of phosphorus.
4. Maximum phosphor-bronze of 4 per cent. of phosphorus.

These three, according to Delalot, are superior to any other bronzes.

Above No. 4 phosphor-bronze is useless, below No. 0 it is inferior to common bronze and steel. Nos. 3 and 4 are comparatively unoxidizable.

Manganese Alloys.—A favorable effect is produced by an addition of manganese to bronze, brass, copper, etc. All varieties of commercial copper as well as bronzes contain more or less oxide which injures the properties of these alloys, especially decreasing their tenacity and malleability. The removal of such admixtures of oxide is effected by substances which have a greater affinity for oxygen than copper, for instance, by an addition of phosphorus in the preparation of phosphor-bronze. Metallic manganese acts, however, far more energetically as it does not volatize like phosphorus at the fusing temperature. For this purpose an alloy of copper and manganese, the so-called cupro-manganese consisting of copper 70.5 parts, manganese

25 and coal 0.5 is recommended. Of this composition an addition of $2\frac{2}{3}$ per cent. suffices for most cases. The process is very simple. After melting the bronze masses the metal-bath is covered with pulverized wood charcoal, and the pieces of cupro-manganese previously weighed and reduced to small pieces are allowed slowly to slide into the crucible. Fusion takes place instantaneously, but the crucible is for a few moments to be replaced upon the fire in order to somewhat increase the temperature reduced by the addition of the cold pieces of metal. In pouring out proceed in the ordinary manner. To enclose the oxide of manganese formed by this process, add to the charcoal with which the metal-bath is covered about one-half its quantity of pure carbonate of soda or potash. The following alloys are prepared according to this method:

1. Tin, 16 parts; zinc, $3\frac{1}{2}$; lead, $3\frac{1}{2}$; cupro-manganese, 1.
2. Tin, 16; zinc, 3; lead, 3; cupro-manganese, 2.
3. *Red Brass.* Copper, 85; tin, 14; cupro-manganese, 1; or copper, 81; tin, 17; cupro-manganese, 2.
4. *White Metal.* Tin, 42; lead, 40; antimony, 20; cupro-manganese, 2.

Ferro-manganese composed of manganese 75 parts and iron 75 can be used for the preparation of sterro-metal; copper, 54 parts; zinc, 40; ferro-manganese, 6.

A composition of cupro-manganese consisting of copper 70 per cent. and manganese 30 per cent. is used as an addition to many alloys, especially for tombac, brass and bronze. By this addition greater density, solidity and extensibility are imparted to the alloys. A copper-tin alloy with 6 per cent. manganese possesses the hardness of steel. For *bearings* the alloy consists of copper, 80 parts; tin, 6; zinc, 5; cupro-manganese, 9. For *rolls* an alloy composed of tin, 64 parts; copper, 8; antimony, 16; lead, 10; and cupro-manganese, 2, is recommended. For *malleable brass*, copper, $56\frac{1}{2}$ parts; zinc, 42; and cupro-manganese, $1\frac{1}{2}$.

Manganese alloys are capable of taking a good polish, and have a white to rose-color color. Cupro-manganese is used in refining copper for the reduction of cuprous oxide, the manganese alloy playing in this case a role corresponding to that of ferro-manganese in the preparation of steel. *Manganese silver* consists of copper 80 per cent., manganese 15, and zinc 5. It is white, takes a good polish and is readily worked.

Manganese Steel.—To the steel melting quietly 80 per cent. ferro-manganese is added in such quantity as desired. The steel is then poured out. To obtain steel with 9 per cent. manganese 0.11 to 0.12 per cent. of the 80 per cent. ferro-manganese, together with 5.5 to 6 per cent. of carbon have to be added. This steel-mixture liquefies with ease. The pieces prepared from it are very resistant to shocks. It is difficult to work with drill or chisel, but can be conveniently hammered and stretched.

Hadfield's Manganese Steel.—The electrical resistance of the non-magnetic manganese steel is 8 times greater than that of ordinary steel and iron and 30 times greater than that of copper. Material with 5 or 6 per cent. of manganese is very hard, with 10 per cent. soft, with 22 per cent. hard. For wrought material the best content is 14 per cent., with not over 1 per cent. of carbon. In France manganese steel is used for horseshoes, whole regiments of cavalry being provided with them.

Malleable Bronze.—A patent has been taken out both in England

and France by Messrs. A. Sentex, C. Marshall and A. Saunier, establishing a process for producing malleable and ductile bronze bars or plates which are free from cracks and blow holes, are "inoxidizable," and which may be "rolled and drawn with the greatest ease." Moreover, have the appearance and "sonorousness of gold." 3.3 lbs. of tin are purified by melting under nitre. 22 lbs. of copper are melted and 1.76 ozs. of equal parts of nitrate and cyanide of potassium are added for the double purpose of reducing the oxides and "fattening" the metal. Then 0.88 oz. of bitartrate of potassium with the same quantity of cyanide is added, and, after poling, the tin is introduced; 0.88 oz. each of sal ammoniac and cyanide are thrown on; 15.43 grains of "phosphuret of copper" introduced to "impart mildness," and 0.7 oz. of "Marseilles soap" added, which still further fattens the metal. Finally, 15.43 grains of sodium are added at the moment of casting. The metal, if cast in sand, may contain zinc, and the proportion of tin be reduced, the quantity of phosphorus and sodium may be increased.

Composition of Some Alloys.

1. *Lazare Weillers.*

Silicon Telephone Wire A.

Copper	99.94	per cent.
Tin	0.03	"
Silicon	0.02	"
Iron	trace.	
Zinc	——	
	99.99	"

Silicon Telegraph Wire A.

Copper	97.12	per cent.
Tin	1.14	"
Silicon	0.05	"
Iron	trace.	
Zinc	1.62	"
	99.93	"

2. *Silicon Brass from Isabellen-Hütte near Dillenburg.*

Copper	71.30	per cent.
Zinc	26.65	"
Lead	0.74	"
Tin	0.57	"
Iron	0.38	"
Silicon	0.14	"
	99.78	"

3. *Mira Metal from Klein, Schanzlin and Becker of Frankenthal.*

Copper	74.755	per cent.
Zinc	0.615	"
Lead	16.350	"
Tin	0.910	"
Iron	0.340	"
Nickel and cobalt	0.240	"
Antimony	6.785	"
	99.995	"

4. *Delta Metal of the "Deutschen Delta-Metall Gesellschaft."*

	Cast. Per cent.	Wrought. Per cent.	Rolled. Per cent.	Hot, Punched. Per cent.
Copper	55.94	55.80	55.82	54.22
Lead	0.72	1.82	0.76	1.10
Iron	0.87	1.28	0.86	0.99
Manganese	0.81	0.96	1.38	1.09
Zinc	41.61	40.07	41.41	42.25
Nickel	trace.	trace.	0.06	0.16
Phosphorus	0.013	0.011	trace.	0.02
	99.963	99.941	100.29	99.83

Locomotive Brass Castings.—*Brasses for Side Rods.* Copper 6 lbs., tin 1 lb.; to 100 lbs. of this mixture add ½ lb. each of zinc and lead.

Brasses for Driving Boxes. The same as for side rod brasses.

Some master mechanics prefer harder brasses, and call for 5 lbs. of copper and 1 lb. of tin, ½ lb. of zinc and ½ lb. of lead.

Bells. Copper 4 lbs., tin 1 lb.; to every 100 lbs. of this mixture add zinc ½ lb. and lead ½ lb.

Castings Subjected to Steam Pressure. Copper 20 lbs., tin 1½ lbs., lead and zinc of each 1 lb.

Pumps and Pump Chambers. Copper 8 lbs., tin 1 lb.; to every 100 lbs. of this mixture add 1½ lbs. each of lead and zinc.

Piston Packing Rings. Copper 16 lbs., tin 2¼ lbs.; to every 100 lbs. of this mixture add 1 lb. each of zinc and lead.

Approved Compositions for Bearings of Rapidly Running Machines. I. Tin 17 parts, antimony 77, copper 6. II. Copper 86 parts, zinc 14. III. Copper 82, zinc 18. IV. Copper 84, zinc 16. V. Copper 100, zinc 10, tin 3. VI. Tin 17.47, zinc 76.14, copper 5.69.

Bearing Metals for Locomotives. I. Copper 86 parts, tin 14. II. *Dutch.* Copper 85.25 parts, tin 127.5, zinc 2. III. *Approved Belgian.* Copper 80 parts, tin 16, lead 2, antimony 2. IV. *French Northern Railroad.* Copper 82 parts, tin 10, zinc 8. V. Copper 87.5 parts, tin 7.88, zinc 5.07. VI. Copper 79.5 parts, tin 7.5, zinc 5, lead 8.

Bearings for Railroad Cars.

Copper. Parts.	Tin. Parts.	Zinc. Parts.	Lead. Parts.
78.7	7.8	6.4	7.4
88	10	2	—
84	16	—	—
82	18	—	—
75	20	—	—
87.7	9.7	2.6	—
90	10	—	—
78	20	2	—

New Alloys.—I. A new alloy, which is said to practically resist the attack of most acid and alkaline solutions, is composed of copper 15 parts, tin 2.34, lead 1.82, antimony 1. This alloy is, therefore, a bronze with the addition of lead and antimony. It is claimed that it can be very advantageously used in the laboratory to replace vessels or fittings of ebonite, vulcanite or porcelain.

II. The following alloy is highly recommended. It is similar to German silver, contains no nickel, but manganese instead. It consists of copper 72½ per cent., manganese 16½, zinc 8¾, iron 2½. It is malleable, does not change when immersed in water for 40 days, takes the silver-plating well, but is a little yellowish.

III. A new and curious alloy is produced by placing in a clean crucible an ounce of copper and an ounce of antimony and fusing them by a strong heat. The compound will be hard and of a beautiful violet hue. This alloy has not yet been applied to any useful purpose, but its excellent qualities, independent of its color, entitle it to consideration.

An Alloy Resembling Gold is obtained by melting together copper 16 parts, zinc 1, and platinum 7. The copper and platinum are first covered with borax, then with pulverized charcoal, and after fusing, the

zinc is added. The alloy thus produced is easily worked, can be drawn out to the finest wire, and never turns blue.

Non-Magnetic Alloys.—I. A new alloy has recently been brought out in Geneva, Switzerland, to be used as a substitute for steel in the manufacture of different parts of watch mechanism, such as hair springs and balance wheels, which are apt to cause a good deal of annoyance through becoming magnetized. It is made from 30 to 40 parts of gold, from 30 to 40 parts of palladium, 0.1 to 5 parts of rhodium, 10 to 20 parts of copper, 0.1 to 5 parts of manganese, and the same proportion of silver and of platinum. The copper and manganese are first mixed, after which the other metals are added, or all the metals may be put into the crucible at the same time, the manganese being used for the bottom layer.

II. Tin, 0.03 part; copper, 58.1; lead, 0.09; zinc, 18.9; iron, 1.28; nickel, 20.62; manganese, 0.98.

Alloys of Copper with Silver and Gold.—The color of the gold alloys depends on the greater or less content of gold and silver. Alloys rich in silver are more whitish, and those rich in copper more reddish. Cadmium gives the alloy a green color, while gray gold is obtained by the addition of steel, as shown in the following table:

COLOR.	Gold.	Silver.	Copper.	Cadmium.	Steel.
Yellow	583	250	167	....	....
Dark yellow	583	125	292	....	....
Very red	583	42	375	....	....
Yellow	666	194	139	....	....
Red	666	67	268	....	....
Yellow	750	146	104	....	....
Red	750	104	146	....	....
Green	750	166	....	84	....
"	746	114	97	43	....
"	750	125	....	125	....
Gray	800	....	....	....	200
"	725	275	....	....	....
"	857	86	....	....	57
Blue	250 to 750	....	....	....	250
Pale yellow	666	333	....	....	....
Pale red	600	200	200	....	....

An Alloy which Expands on Cooling may be prepared from lead, 9 parts; antimony, 2; bismuth, 2. It is well adapted for filling out small holes and bad places in cast-iron.

Acid-Resisting Bronze.—This bronze is patented in Austria, and is claimed to possess an extraordinary power of resisting acids and alkalies, and therefore can be advantageously substituted for hard rubber, porcelain, and other substances. It is composed of copper, 15 parts; tin, 2.34; lead, 1.82; and antimony, 1. The metals are fused together in the usual manner, and the alloy is worked like ordinary bronze.

Alloys of Lead, Antimony, and Tin.—These alloys are readily fusible, and very useful for cheap cast articles which may be silvered:

	Tin.	Antimony.	Copper	Zinc.	Lead.	Various.
Britannia, English	81.90	16.25	1.84	....	....	....
" "	90.62	7.81	1.46	....	....	....
" "	90.1	6.3	3.1	0.5	....	....
" "	85.4	9.66	0.81	3.06	....	....
Pewter	81.2	5.70	1.60	....	11.5	....
"	89.3	7.6	1.8	....	1.8	....
Tutania	91.4	....	0.7	0.3	7.6	....
Queen's metal	88.5	7.1	3.5	0.9	....	....
Britannia, German	72	24	4	....	....	....
" "	84	9	2	5	....	....
" "	20	64	10	6	....	....
" "	48	....	3	48	1	....
Biddery metal	....	....	3.5	93.4	3.1	....
" "	1.4	....	11.4	84.3	2.9	....
Ashberry metal	8	14	2	1	....	2 nick'l
" "	79	15	3	2	....	1 nick'l
Minofor metal	66	20	4	9	....	1 iron
Type metal	....	25	....	....	75	....
" "	10	18	2	....	70	....
" "	20	25	....	....	55	....
" "	....	....	4	90	6	....
" " English	22.1	22.7	....	....	55	....
" " "	9.1	19.5	1.7	....	69.2	....
Fahlun brilliants	60	....	....	....	40	....
Organ-pipe metal	71.4	....	....	....	28.6	....
Music-plate metal	60.0	5.4	....	....	34.6	....
Metal for toys	57.2	....	....	....	42.8	....

German Silver Alloy.—The alloy is composed of German silver, with an addition of 1 to 10 per cent. of tin, 1 to 5 per cent. of manganese, and 1 to 5 per cent. of 15 per cent. phosphor-tin or phosphor-copper. It is claimed to be especially suitable for casting articles with thin walls.

Sideraphtite.—An alloy, to which this name is applied, consists of iron, 65 parts; nickel, 23; tungsten, 4; aluminium, 5; and copper, 5. It is claimed to completely resist the action of sulphuretted hydrogen and vegetable acids, and to be quite indifferent towards mineral acids.

Bismuth-bronze consists of copper, 52 parts; nickel, 30; zinc, 12; lead, 5; and bismuth, 1. This alloy resists oxidation, and seems to be especially suitable for the manufacture of lamp-reflectors, metallic mirrors, etc.

Alloy for Moulds for Iron Founding.—The following alloy is distinguished by great hardness and strength, and by being but slightly subject to oxidation: 100 parts of 10 per cent. aluminium-bronze, 2 parts of zinc, 0.5 part of manganese, 1.5 part of lead, 2 parts of tin, and

0.25 part of phosphorus. Melt until the alloy has reached a melting point of 1482° F., and then pour into ingots. A very pure and homogeneous metal is obtained by recrystallizing the alloy once more. With a specific gravity of 8.3, the hardness of the alloy is 3.4; its strength of extension 171.66 lbs. per 0.155 square inch, and its melting point 1482° F.

Alloys of Copper with Nickel.—Pure copper-nickel alloys are used for the fabrication of small money, the Belgian, German, United States, and Brazilian coins consisting of nickel 25 parts and copper 75.

Another kind of nickel alloys consists of copper, zinc, and nickel, and are known as German silver or argentan:

	Copper.	Zinc.	Nickel.	Iron.	Cadmium.	Tin.	Silver.
German silver:							......
English, best quality	8	3.5	4	......	......	......	......
" refractory......	8	3.5	6	......	......	......	......
" ordinary.......	8	6.5	3	......	......	......	......
German, best quality	52	26	22	......	......	......	......
" second " ...	59	30	11	......	......	......	......
" third " ...	63	31	6	......	......	......	......
Chinese white copper...	79.40	....	16.02	4.58	......	......	......
Paris argentan......	69.8	5.5	19.8	......	4.7	......	......
" oreide...............	79.7	....	13.05	0.28	......	0.09	......
Ruolz metal..............	37 to 42	....	20.0	......	......	......	33
" "	30 to 40	....	45 to 55	......	......	......	40
" "	45 to 55	....	25 to 35	......	......	.....	20
" "	41.8	16.3	8.6	......	......	......	33
" "	42	16	8	......	......	.....	34
" "	44.6	10.8	4.6	......	......	......	40
Packfong A	40	25	31	......	......	......	......
" B................	43	40	16	......	......	......	......
" C................	45	21	33	......	......	......	......
"	40.4	25.4	31.6	......	......	2.6	......

Tombac (Red Brass).—To obtain great hardness together with the utmost ductility in tombac or red brass without the addition of commercial phosphor-bronze, green bottle-glass may be advantageously used. For this purpose reduce the glass to a powder in a mortar, and use ½ lb. of the powder for 25 lbs. of metal. Care must be had to place the entire quantity of glass upon the bottom of the crucible so that the metal lies on top. The metal obtained is very hard and can scarcely be worked. This alloy is especially suitable for an addition to every other alloy. If the alloy is to be used by itself for castings 1 per cent. of manganic oxide has to be mixed with the metal.

Fusible Alloy.—An alloy which melts at a lower temperature than

the magic spoon is obtained by melting together 48 parts bismuth, 31 of cadmium, 10 of lead, and 20 of zinc. This alloy melts at 135° F.

Alloys of Cadmium and Bismuth.—These alloys have the peculiarity of their melting points being far below those of the constituent metals. Some of them melt even in hot water. They can, therefore, be employed for casting in moulds not capable of standing great heat, for instance, paper, wood, plaster of Paris, etc. The most important of these alloys are found in the following table:

	Melting point. Degrees F.	Lead.	Tin.	Antimony.	Cadmium.	Bismuth.
Lipowitz's alloy.........	158	8	4	.....	3	15
Readily fusible alloy...	169.8	11	3	......	2	16
" " "	167.0	8	3	......	10	8
" " "	203.0	......	2	......	1	3
" " "	150.0	2	1	......	1	4
Wood's alloy.............	143.6 to 161.6	4	2	......	1 to 2	5 to 8
Soft solder.................	179.6	6	......	......	1	7
" "	300.2	2	4	......	2	....
Cliché metal.............	....	50	36	......	22.5	....
" "	....	32.5	48	......	10.5	9
Metallic cement.........	....	8	......	3	....	1
Newton's metal..........	202.0	5	3	.....	....	8
Rose's metal..............	200.5	1	1	......	....	2
" "	274.2	8	3	......	....	8
Readily fusible metal for casts from plaster of Paris moulds, etc.	....	13	3	......	....	6
	....	3	2	......	....	5
	....	1	1	......	....	2
	....	5	3	.....	....	8
Glass cement..............	212.0	3	2	......	....	2.5
Bismuth alloys...........	212.0	5	3	......	....	8
" "	235.9	8	4	......	....	8
" "	253.9	8	8	......	....	8
" "	266.0	10	8	......	....	8
" "	270.3	12	8	......	....	8
" "	289.9	16	14	......	....	8
" "	293.7	16	12	......	....	8
" "	308.8	22	24	......	....	8
" "	320.3	32	36	......	....	8
" "	331.7	32	28	.....	....	8
" "	341.6	30	24	......	....	8

Iron Alloy.—A compact, very malleable iron alloy capable of taking a high polish has been patented in England by W. M. Arnold. It is obtained by melting together pig iron, 50 lbs.; sodium, ½ lb.; copper and antimony, each, ¼ lb., and zinc, 2½ lbs. It is claimed to be especially suitable for ships' screws, it resisting quite well the corroding action of sea-water. By omitting the sodium and decreasing the quantity of zinc a softer variety of iron is obtained, while the addition of larger quantities of soda and zinc and the decrease of the content of copper yield a harder material.

BONE, IVORY, MOTHER-OF-PEARL, WOOD.

To Stain Bone and Ivory Brown.—Free the articles as much as possible from adhering grease by treating them with petroleum ether or so-called sulphuric ether. On account of the great inflammability of these two bodies, this work should never be done by lamp-light or in the neighborhood of a flame. After being freed from grease the articles are placed 5 to 15 minutes at the ordinary temperature of a room in a mixture of 1 oz. 7 drachms of hydrochloric acid and 1 quart of water. They are then thoroughly washed with water and placed in a solution of 2.82 drachms of potassium permanganate in 1 quart of water. Care must be had that the solution when it is to be used does not contain undissolved crystals of the potassium permanganate which might give rise to a spotted coloration. According to the shade of color desired, the articles remain for a shorter or longer time in the solution, which, however, must not be heated. The article having acquired the desired degree of coloration, it is taken from the solution, washed with water, and, after drying, polished in the usual manner.

In order to obtain more reddish colorations the article after polishing is placed in a solution of fuchsine, or still better, in one of a variety of fuchsine known as grenadine, which is prepared by dissolving 5.64 drachms of the coloring substance in 1 quart of water. In a short time the pure, brownish coloration passes into a reddish brown, which by continued treatment with the last mentioned solution can be still further changed to red without losing the fundamental color.

To make Horn Buttons Iridescent.—Dissolve 10 parts of pure methyl-violet in 80 of 95 per cent. alcohol, filter the solution through filtering paper and add 4 parts of sandarac, the solution of which is accelerated by frequent shaking. The sandarac being dissolved, liquefy ½ part of Venetian turpentine in a suitable vessel over a fire and pour the liquid, after taking it from the fire, with constant stirring, into the sandarac solution and allow the whole to stand a few days to permit the impurities contained in the sandarac to settle. The buttons sewed upon cards are then uniformly lacquered by means of a fine camel's hair brush, care being had not to soil the cards.

The buttons now show a brown, copper-like, metallic lustre, which can be converted into iridescent colors by various chemical agents. By brushing the buttons with dilute hydrochloric acid, a surface showing all the colors of the rainbow is obtained; the same effect being also produced by simply moistening with saliva. A pale red iridescent coloration is produced with vinegar; by repeating the application several times the color approaches that produced with hydrochloric acid. To impart to the buttons a dark green iridescent color, brush them lightly over with a rag moistened with oil, care being had to wipe the buttons dry immediately afterwards with a woolen rag. Similar effects are produced by aqueous solutions of ferrous sulphate, cupric sulphate, potassium bichromate, common salt, borax, and many other salts. With permanganate of potash all colorations from pale red to dark red, violet, blue, and green can be produced. The less concentrated the solution, and the shorter the time it is allowed to act, the paler the coloration produced will be.

Dissolve 1 part of permanganate of potash in 16 of distilled water; and to produce a green iridescent color brush over the buttons sewed upon cards with the solution. By further diluting this concentrated solution with 8 parts of water the buttons acquire a blue iridescent color, and by a further addition of 8 parts of water a violet iridescent color; by further dilution a dark red iridescent color is obtained, and by still further adding water a pale red iridescent color.

To Cleanse Ivory Ornaments.—These are very quickly cleaned by brushing them with a new, not very sharp, tooth-brush to which little soap is given; then rinse the ornaments in lukewarm water. Next dry and brush a little and continue brushing until the lustre reappears, which can be increased by pouring a little alcohol upon the brush and applying it to the trinket. Should this have become yellow dry it in a gentle heat and it will appear as if new.

Dyeing Mother-of-Pearl.—Mother-of-pearl is dyed by allowing it to remain for several days in an ammoniacal solution of nitrate of silver (1 nitrate, 80 distilled water, and 20 water of ammonia); remove the pieces and subject them to the action of a current of sulphuretted hydrogen till the desired shade is obtained.

Impregnation of Wooden Barrels, etc., for the Reception of Fat, Oil and Petroleum.—Dissolve in 1000 parts by weight of filtered water 110 of ferrous sulphate (copperas), and after adding for every 400 parts by weight of the solution 200 to 500 parts of glue allow the whole to stand 12 hours. Then add for every 500 parts by weight of glue 600 of molasses, 20 of cane sugar, and finally 600 of solution of ferrous sulphate. Heat upon a water-bath, whereby the mixture becomes fluid, and apply to the surface of the wood by means of a brush. For barrels pour a suitable quantity through the bung-hole, and roll so that the interior is uniformly coated with the mass.

Impregnation of Wood.—By allowing masses of lime to remain in contact with solutions of fluo-silicic acid, calcium fluoride (fluorspar), calcium silicate and silicic acid are formed, the fluo-silicic acid being decomposed. If, now, the above-mentioned reactions take place in a porous wood which has been successively impregnated with the above-stated solutions of lime and silicic acid, fluorspar, calcium silicate, and silicic acid are formed within the wood substance, and, so to say, petrify the wood. By simultaneously using, besides the above-mentioned agents, bituminous, resinous, fatty, or oily substances for the impregnation of the wood, the latter is rendered capable of resisting the influence of moisture, and is at the same time, so to say, mineralized. Van Berkel's method of impregnating wood, which is based upon the above-described process, consists in treating the wood to be impregnated with a saturated solution of lime water or of milk of lime for some time, according to the porosity of the wood, and then drying. With the use of a vacuum impregnating boiler the dry calcareous wood is then impregnated with a suitable mixture of silicic acid with a mineral oil or other bituminous, resinous, fatty, or oily fluids, which are previously heated to render them more thinly fluid. The wood is kept for some time under pressure and then again dried. The operation may also be carried on in the reverse order, or in such a manner that the fluo-silicic acid, lime, and bitumen are introduced into the wood each by itself, or

first the fluo-silicic acid and then the bitumen mixed with milk of lime. Besides lime water other reagents brought into combination with silicic acid might permit the practical execution of the invention and produce the petrifaction of the wood. If, for instance, a block of wood is impregnated with dilute water-glass or alum, there remain in the wood substance, after the evaporation of the water by drying, silicic acid and soda, or aluminium as a residue. By a further impregnation with a mixture of bituminous substances and silicic acid, silicic acid and cryolite are obtained in the wood, petrifying the wood-substance with still better technical effect and, in consequence of the presence of the bitumen, rendering it at the same time impermeable to moisture.

To Prevent Warping of Wood and of wooden objects in damp air, saturate them with copaiba balsam. Articles already warped on one side can be straightened by saturating the other side with the balsam.

To Preserve Wooden Posts.—The ends of the thoroughly dry posts which are to be put in the ground are placed in lime water 1.18 to 1.57 inches deep, and after taking out and drying, painted with diluted sulphuric acid. The posts thus treated become hard as stone and are far more durable than when carbonized or coated with tar.

Stain for Oak.—Boil for half an hour 2 ozs. 13 drachms of dry sodium carbonate and 8 ozs. 13 drachms of finely prepared pale ochre in 2 quarts of rain water and then add 2 more quarts of water. To this stain add 24 ozs. 11 drachms of a mass prepared by boiling 1 lb. of yellow wax, 2 quarts of water and 2 ozs. 7 drachms of potash and stirring till cold.

Darkening the Natural Hue of Wood.—This is effected by a solution composed of equal parts of manganate of soda and crystallized Epsom salts, dissolved in twenty to thirty times the amount of water at about 144° F. The less water employed the darker will be the hue.

To give New Oak Wainscoting and Furniture an Antique Appearance.—Oak is fumigated by liquid ammonia, strength 880 degrees, which may be bought at any wholesale chemist's. The wood should be placed in a dark and air-tight room (in a big packing case if you like) and half a pint or so of ammonia poured into a soup plate and placed upon the ground in the centre of the compartment. This done shut the entrance and secure the cracks, if any, by pasted slips of paper. Remember that the ammonia does not touch the oak, but the gas that comes from it acts in a wondrous manner upon the tannic acid in the wood and browns it so deeply that a shaving or two may actually be taken off without removing the color. The depth of shade will entirely depend upon the quantity of ammonia used and the time the wood is exposed.

Ebony Color upon Wood.—Boil 1 part of logwood with 10 of water, strain and evaporate to one half the volume. To 1 quart of the fluid thus obtained add 10 to 15 drops of a neutral, thoroughly saturated solution of indigo and apply the decoction several times to the wood previously stained with a hot saturated solution of alum. Next brush the wood over with a hot concentrated solution of verdigris in acetic acid until the desired black shade is obtained.

A Beautiful Gray-green color upon wood is produced by first brushing the wood over with a solution of 1 part of pyrogallic acid in 20 of water and after drying with a solution of 1 part of aniline green in 12 of alcohol.

A Dark Green is obtained with a solution of 1 part of indigo blue in 5 of water mixed with a concentrated solution of 2 parts of pure picric acid in boiling water.

To Color Wood Black.—Hard woods (oak, ash, beech, maple, etc.) are rubbed with glass paper, placed in an alum solution (1 : 18) which contains 2 per cent. of glycerine, and dried. The wood is then impregnated with the following coloring substance: Boil for 1 hour, constantly replacing the water lost by evaporation, 1 part of logwood, 10 of gall nuts and 100 of water. Then press out and filter and with constant stirring and heating add the solutions of 1 part of sulphate of iron and 1 part of copper acetate each in 2 parts of water. Filter the mixture and finally add 1 part of indigo solution. The wood impregnated with this coloring substance and dried at an ordinary temperature is brushed over with a solution of 1 part of iron powder in 10 of vinegar and when thoroughly dry vigorously rubbed with a mixture of 4 parts of linseed oil and 1 of oil of turpentine.

Ivory Gloss on Wood.—There are two kinds of varnish used to produce this white gloss—one a solution of colorless resin in turpentine, the other in alcohol. For the first, pure copal is taken; for the second, 16 parts of sandarac are dissolved in sufficient strong alcohol to which are added 3 parts of camphor; and lastly, when all are dissolved by shaking, 5 parts of Venetian turpentine are added. In order to cause the color to remain a pure white, care must be taken not to mix the oil with the white paint previously put on. Best French zinc paint mixed with turpentine is to be employed. When dry this is rubbed down with sand-paper, and this is followed with the application of the varnish above described.

Crystalline Coating upon Wood or Paper is obtained by mixing a very concentrated solution of salt with dextrin and applying a coat of this fluid as thin as possible to the surface to be coated by means of a broad, soft brush. The dry coating presents a beautiful light mother-of-pearl appearance, and by means of the dextrin adheres firmly to the wood or paper. Such a coating can also be applied to glass by previously coating the latter with an alcoholic solution of shellac. The following salts are best adapted for the formation of the most beautiful crystalline coatings: Sulphate of magnesia, acetate of sodium and sulphate of tin. The paper must be sized. Colored glass gives a good effect.

To protect Wood Exposed to the Influence of Acids and High Tension of Steam, the following process is recommended: Mix intimately 2 parts of plaster of paris and 1 part of finely pulverized asbestos with fresh ox blood to a thick paste which can be applied with a brush. The wood, which should be thoroughly dry, is then painted with this mixture and allowed to dry. After a few hours a second coat is given to which a very small addition of linseed oil varnish may suitably be made. To secure complete hardening of the coats a small charcoal fire

over which the wood is suspended may be used, though air-drying for a few days suffices. Steam is then allowed to act slowly upon the wood and the latter dried for some time before use. With proper treatment the coat adheres firmly, does not show fissures nor crack off.

Prevention of Worms in Wood Work.—Some woods are more subject than others to be destroyed by worms and insects, such as alder, beech, birch, and in general all soft woods, of which the juices are of a saccharine nature. Against the common worm oil of spike is an excellent remedy; and oil of juniper or oil of turpentine will prevent its ravages to some degree. A free use of linseed oil is a good preservative, and so is a covering of copal varnish; but these can be applied to small articles only. Another application is sulphur, which has been immersed in nitric acid and distilled to dryness, which, being exposed to the air, dissolves into an oil; the parts to be secured from the worm are to be anointed with this oil, which does not give an unpleasant odor to the wood. Lime is an excellent preservative against the worm, and sap-wood should always be impregnated with it when used in a dry situation. As worms do not attack bitter woods, soaking wood in an infusion of quassia has been tried, and is said to have the desired effect.

To Give Wood Some of the Special Characteristics of Metal.—By this recently invented process the surface of the wood becomes so hard and smooth as to be susceptible of a high polish and may be treated with a burnisher of either glass or porcelain; the appearance of the wood being then in every respect that of polished metal, having, in fact, the semblance of a polished mirror, but with this peculiar and advantageous difference, that, unlike metal, it is unaffected by moisture. To reach this result the wood is steeped in a bath of caustic alkali for two or three days together, according to its degree of permeability, at a temperature of between 165° and 197° F. It is then placed in a second bath of hydrosulphate of calcium to which a concentrated solution of sulphur is added after some 24 or 36 hours. The third bath is one of acetate of lead at a temperature of from 95° to 120° F., and in this latter the wood is allowed to remain from 30 to 50 hours. After being subjected to a thorough drying, it is in a condition for being polished with lead, tin, or zinc as may be desired, finishing the process with a burnisher, when the wood apparently becomes a piece of shining, polished metal.

Imitation of Wood Carving.—Old oak or other carvings in low relief may be very effectively and easily imitated, almost in fac-simile, by the following process: Procure some "basil" leather, and wet it thoroughly in warm water in which a small quantity of size or glue has been mixed; wipe it as dry as possible with a cloth, then cut a piece sufficiently large to cover the carving and allow a small margin; lay it upon the carving and press with the finger all over, in order that the leather may take the shape of the carving as much as possible. Next, with a smooth-pointed tool made of bone—say the handle of a tooth brush, filed down till it assumes a blunt knife shape—go over the surface carefully, pressing the leather into all the interstices of the design and smoothing the larger or bolder portions until you have succeeded in bringing out all the details. Of course, this process can only be applied to carvings which are not under-cut. If the superfluous moisture has

been removed from the leather in the first instance, it may now be easily taken from the carving without interfering with its shape, but if not, it must be left until partially dry. When taken off the leather should be placed in a warm place to dry thoroughly, when it will be found to be quite stiff and may be coated thickly at the back with a layer of gutta percha, or with the following mixture: Pitch, resin, plaster of paris, equal parts; melt the pitch and resin together, and then stir in the plaster of paris. If a small quantity of wax candle be added to the mixture it will be rendered tougher. The imitation may now be applied to the use for which it was intended, and if treated with dark distemper oak stain and oiled, will look wonderfully like genuine carved oak.

Waxing Hard-Wood Floors.—One of the best methods of preparing the wax and waxing the floor is as follows: Take a pound of the best beeswax, cut it up into very small pieces and let it thoroughly dissolve in 3 pints of turpentine, stirring occasionally if necessary. The mixture should be only a trifle thicker than the clear turpentine. Apply it with a rag to the surface of the floor, which should be smooth and perfectly clean. This is the difficult part of the work, for if you put on either too little or too much, a good polish will be impossible. The right amount varies, less being required for hard, close-grained wood and more if the wood is soft and open-grained. Even professional "waxers" are sometimes obliged to experiment, and novices should always try a square foot or two first. Put on what you think will be enough, and leave the place untouched and unstepped on for 24 hours or longer if necessary. When it is thoroughly dry rub it with a hard brush until it shines. If it polishes well, repeat the process over the entire floor. If it does not, remove the wax with fine sand-paper and try again, using more or less than before, as may be necessary, and continue your experimenting until you secure the desired result. If the mixture is slow in drying, add a little of the common "driers" sold by paint dealers, japan for instance, in the proportion of 1 part of the drier to 6 parts of turpentine. When the floor is a large one you may vary the tedious work of polishing by strapping a brush to each foot and skating over it. A properly waxed hard wood floor renders an engine room always attractive, it giving the room an appearance of neatness and comfort.

Veneering.—The modern art of building calls for a large variety of finished work, especially for interiors. Many domestic woods, and nearly all of the foreign products, may be used for veneers. Of the first we have walnut, maple, cherry and oak; while of the foreign woods the list comprises, in addition to the above named, tortoise (or zebra) wood, ebony, mahogany, rosewood, sandal wood, holly, baywood and satinwood.

The first process to insure good work is to prepare the panel or piece of work to be veneered, in a perfect manner; that is, the piece should be thoroughly dry; natural dried wood is the best, but kiln-dried lumber will do under many circumstances.

The surface should be perfectly straight and out of wind. This may be done with the trying-plane, after being jointed. Then follow with a toothing-plane, first with the grain and then crosswise. If white or yellow pine is used a coarse toothing-plane is best. It may here be mentioned that pine or soft wood is the best, and should always be used

as a base for veneering, as the glue has the effect of penetrating better than in hard, close-grained wood.

After toothing use No. 2 or 2½ sand-paper crosswise and do the work thoroughly. Having prepared all the panels or work in this way, proceed to size them with one part of the best glue, boiled in 50 parts of water, prepared in a double glue-pot in the usual manner. Brush over the panel with hot glue, and after having gone over the work thoroughly and allowing it to dry (having glue-sized all the work) go over it again with a view of detecting any defects not filled; if found, fill them with plaster of paris wet up in water; and touch up these parts with glue-size. See that the work has a smooth, even surface. If not, level it off with a flat rasp. In preparing the veneer, which may be had of any required thickness from dealers, select the parts best adapted for the work to be done, as the centres of panels or prominent places likely to be seen. Cut the veneer rather larger than the panel or piece to be veneered, to allow for leveling at the ends and sides. If the veneer is uneven in surface, or curled badly, as is the case with some selected pieces, dampen the back, and if there is more than one piece, lay them together, the first with the dry side upward and the second the same way, thus bringing a dry and wet side together; let them stand, say 5 hours, when they will be ready to cut.

The next process for getting each veneer flat and ready to lay smoothly, is to place each piece between two smooth pieces of pine a little larger than the veneer. The pine pieces should be heated hot before a bright fire; then placing each veneer between them, apply hand-screws for half an hour, and they will come out perfectly flat; prepare each separate veneer in this way, and if the first damping and pressing does not bring them out, try until it does. This is termed *flatting*.

Veneers sometimes come with serious defects, or holes, which require filling. To remedy this evil, select a small piece of the veneer that has been flatted, and which best matches the grain to be patched or filled; place it under the hole, and cut it out square or angular, as is deemed best; cut both at the same time with a chisel or knife-blade.

If the veneers are in small pieces and not large enough for the finished panel, and they must be matched, select the several pieces so that they will appear to the best advantage when in the panel; then turn them face upwards and fit to them narrow strips of thin but strong paper; after cutting the joints of the veneers to match nicely, glue the strips of paper on the face over the joint, a little distance apart, and press down on a flat board with a damp cloth. Before joining the two veneers together, secure them in place with small tacks, to hold them temporarily. Glue the joints and cover with paper on the face, as before mentioned, say strips 2½ inches wide. After they are all prepared lay them away under a board to keep from curling and drying too quickly.

The next process is laying. This process is generally done with a veneering caul. To make a caul take a piece of dry pine rather larger than the surface to be veneered; have it true and flat, and if large, put one or two good battens on the back; then cover the face with zinc and tack the edge over the edge of the caul. For laying use the very best glue, prepared in the most careful manner, as glue is the life of good veneering. When prepared so as to spread smoothly under a medium-sized brush, and the veneers and caul are close at hand, heat the caul on a stove or before a hot fire; glue the ground-work or panel;

place the veneer in position, and press gently over it with the hand; then place the hot caul on the veneer, first rubbing the caul with a greased cloth. Put on the hand-screws and clamps, slowly tightening them up. They should be about 4 to 6 inches apart. Give them all the same pressure, as near as may be. Let the caul remain for one hour. When taking it off, if it sticks on account of not being well greased, a thin knife-blade or chisel will pry it up; but it should be done carefully. If there should be any blistering, showing that the glue was not well spread out, put on a small caul, enough to cover the spot, and let it remain on for two hours. After the veneer panel, or work, has stood, say two or three days, scrape off the paper on the face, first wetting it with hot water; use a steel scraper, or chisel, for thin veneer, or a smoothing plane for thick. Finally size the face of the veneer with thin glue and rub off with a cloth or the hand. When dry, it may be fine sand-papered and smoothed up and finished in oil, or in any way thought best. The introduction of muslin or paper between the base and veneer is a method which requires considerable practice and is not necessary in small work.

Another and new method of securing veneers to the base consists in first spreading the glue, or any other substance used for the purpose, upon the base, passing the two parts between two heated rollers, which melts the glue to a proper consistency for entering the pores of the wood. The veneered pieces are then passed between chilled rollers, which sets and hardens the glue, and thus prevents the shrinkage caused by slow drying, which is one of the difficulties of veneering by hand. Very thin veneers are now manufactured and furnished to the trade with paper backing; that is, the veneers are exceedingly thin and backed up with a strong, thin paper put on with glue. When using this kind of veneer, it can be put on without glue or caul, the advantage being that it can be applied on wood or walls with flour paste.

Gilding of Wood Moulding, Cornices and Frames.—Put boiled linseed oil in a saucer and expose it to the air for three or four days carefully protected from dust; then mix it with a little yellow ochre ground in oil and give the frame a coat of this, and let it stand for 24 hours, when the frame will be ready to receive the gilding. Another mode of preparing the frame is to cover it successively with 8 or 10 coats of size mixed with whiting. The last coat is composed of size and massicot, sometimes yellow ochre. Let it dry thoroughly, and then dampen the surface a little at a time with a wet sponge and apply the gold leaf before this dries; it will immediately adhere. Take a piece of tissue paper about 2 inches square, rub one side of the paper lightly over with beeswax or composite candle, then cut the leaf the size of the frame and apply, rubbing gently with the finger, and when the whole frame is covered, pat gently with cotton wool. Each piece should overlap $\frac{1}{16}$ inch. In gilding with a tip, the frame should be painted with white paint three times, then let it harden and afterwards rub well with fine glass cloth. Then apply oil gold size and put the frame aside from dust until it is only slightly damp. There is a particular state, or degree of dryness, known only by experience, in which the moulding is in a fit state for burnishing. A large share of the elegance which a golden frame presents is due to the judicious mixture of burnish and matt or dead gold, and the gilder determines what members of the moulding shall be burnished. The burnishers used by the gilder are either of flint or agate, generally the

former. The steel burnishers employed by the jeweler would not do for the gilder. It frequently causes surprise that the burnisher can be rubbed briskly over the gold without injuring or rubbing it off, but it is to be remembered that there is a yielding foundation into which the gold is pressed, and that the brilliancy attained is derived from leveling the little asperities in the gold and the gold size beneath it. If gold were laid on wood or even on whiting it would not receive a burnish.

Novelty in Inlaid Floors.—A novel and beautiful improvement in inlaid floors has been devised by Christian Momberg, of Copenhagen, Denmark. The novelty in this improvement consists in the varied styles of ornamental flooring which it is possible to produce. This improved inlaid or marquet flooring consists of beams or joists provided with rabbetted edges and a series of intermediate filling strips having grooves in their end edges, the grooves fitting over the upper tongues formed by the rabbetted edges of the joists. The filling strips are also provided on their side edges with longitudinal flanges. The joists are laid transversely across and secured to the usual supporting girders in any desired manner, and, in practice, the filling strips are introduced from the open end of the frame, the grooves of the strips engaging the upper flange of the joists. The lower flanges formed by the rabbetted edges of the joists extend laterally a greater distance than their upper flanges, thereby assisting to support the intermediate pieces and also the filling blocks. These filling blocks are square or rectangular in shape, having on their edges, which border on the joists, grooves similar to those in the end edges of the filling strips, and also provided on their other two edges or sides with under cuts adapted to overlap the flanges of the filling strips, thereby bringing the upper surface of these blocks flush with that of the intermediate filling strips. By this construction the upper tongues formed by the grooved edges of the filling blocks and intermediate filling strips will overlap the upper tongues of the joists, making a filling space throughout the entire length of the joists, which may be filled with veneering of any ornamental design or pattern, thus producing an even floor, the strips of veneering being of sufficient thickness to fill in the space above the joists.

In constructing this floor, the filling strips, as stated, are first introduced from the open end of the frame, after which a row, or series of filling blocks is inserted, the upper tongues of the joists, as in the case of the filling strips, engaging the grooved ends of the blocks. In this manner the filling strips and blocks are inserted in regular order until the flooring has been completed. The filling strips and blocks are decorated upon their upper surface in any ornamental pattern corresponding in design to the veneering above the joist. By employing this method of constructing inlaid flooring, not only does the inventor avoid the expense, but also the various other drawbacks incident to the use of the ordinary wooden floors under the inlaid flooring, the chief objection to that construction being that the planks which are placed under the veneers are often uneven, or become so by shrinkage or from other causes. Whenever this happens the warping of the underlying floor will, of course, affect the inlaid floor more or less, thus marring its effect and also destroying its durability.

To Prevent Exudations of Turpentine from Pine-wood.—To prevent exudations of turpentine from painted pine-wood it is rec-

ommended to cover the knots in the wood, before applying the paint, with a mixture of equal parts of slacked lime and red lead. On drying, the mass absorbs the turpentine in the same manner as oil is removed from a floor by means of pipe-clay. By several times repeating the process the exudations of turpentine after painting is prevented.

To Remove Paint from a Wooden Carving without Damaging the Wood.—Mix one part by weight of pearlash with three parts lime by slacking the lime in water and then adding the pearlash, making the mixture about the consistency of paint. With an old brush lay the above over the whole of the work required to be cleaned; let it remain 14 or 16 hours, when the paint can be easily scraped off.

BRONZING, COLORING, ELECTROPLATING, ENAMELLING, ETC., OF METALS.

Bronzing of Tin.—Prepare first two solutions, one of 1 part ferrous sulphate (green vitriol), 1 part cupric sulphate (blue vitriol), and 20 parts of distilled water, and the other of 4 parts verdigris and 16 parts vinegar. Thoroughly clean the article by means of a clean brush with a fine earth and water, and after thorough drying apply to both sides a light coat of the first solution by means of a brush. After drying the article presents a blackish appearance. The second solution is then applied with a brush until the article acquires a dark copper-red color. It is now allowed to dry one hour and then polished with a soft brush and finely elutriated bloodstone, the surface being frequently breathed upon so as to make the bloodstone adhere. It is finally polished with the brush alone, which is from time to time drawn over the palm of the hand. To protect the bronze against moisture cover it with a very thin layer of gold lacquer.

To Bronze Zinc Fret Work.—Coat the metal with a very thin gold size, and when nearly dry rub on a sufficient quantity of red bronze (bronze powder), dry, and burnish.

Bronzing Copper.—Dissolve in 11 gallons of hydrochloric acid as much as possible of iron in fine wire or scales. When the liquid is saturated a deposit will form at the bottom. Then add 2.2 lbs. of arsenious acid and stir vigorously. When the acid is dissolved the bath is complete. The objects to be bronzed are connected to the negative pole of a battery, the opposite electrode being formed of rods or plates of retort carbon. Articles of copper or brass become black at once, but those of iron are attacked by the bath. It is therefore necessary to nickel the latter. In order to preserve the deposit of iron the surface must be lacquered.

To Bronze Steam Pipes used for Steam Heating.—Paint the pipes with ordinary chrome yellow and, when nearly dry, rub gold bronze powder upon the surface with a piece of fur. When thoroughly dry varnish the surface with a very thin copal or mastic varnish.

Approved Coatings for Metals.—1. *Black or Colored Coat.* Dissolve flowers of sulphur, about 5 to 10 per cent., in hot oil of turpentine and gradually add to the solution with constant stirring a corresponding quantity of linseed oil varnish. A black paint is obtained by the addition of solution of asphalt, and any other desired color by mixing with non-metallic coloring substances. This paint protects the metal coated with it by superficially converting it into sulphur combinations.

2. *Golden Yellow to Brown Coat.* Place a sufficient quantity of vulcanized rubber in small pieces in an earthen pot provided with a well-fitting lid upon glowing coals for 5 minutes; do not remove the lid as the vapors developed are very inflammable. Pour the melted mass into a tin dish to cool; for the easier removal of the cooled mass it is advisable to slightly grease the tin dish. Next break up the mass into small pieces, put them in a capacious bottle, pour benzine and rectified oil of turpentine upon them and shake frequently until all is dissolved except a slight sediment. The fluid poured off from the sediment is an excellent quickly-drying varnish which adheres firmly to metals and can also be recommended for electrical apparatus.

3. *Black Coat.* To obtain this it is first necessary to procure very good and pure platinum chloride. It is best prepared by dissolving platinum in *aqua regia* (3 parts hydrochloric acid and 1 nitric acid). By evaporating the solution the desired platinum chloride is obtained in the form of crystals which are dissolved in water. A very beautiful and durable black color is produced upon the articles by dipping them into the solution or coating them with a moistened sponge. The same effect is also produced by allowing the crystals to deliquesce in the air and vigorously rubbing the metal with the moist powder by means of a piece of leather, or smaller articles with the thumb or palm of the hand. To obtain good results the articles to be blackened must be given a pure metallic surface by turning or in some other manner, carefully polished and especially freed from adhering grease by rubbing with Vienna lime, jewelers' rouge, etc. Various shades of color can be produced. The articles treated as above described are dead black; a lustrous black color is obtained by polishing with a soft piece of leather moistened with oil, and a lustrous gray-black color by polishing with the burnisher or burnishing stone. The color, especially when polished, is very durable, since platinum is not changed by the action of the air. A black color may also be obtained by the following process: First brush the article over with nitric acid and after drying by heating brush vigorously to obtain uniformity. Then lay the article over a vessel containing solution of liver of sulphur and expose it to the action of the developing sulphuretted hydrogen.

4. *Beautiful Steel Gray.* This coating is obtained by the use of a mixture prepared as follows: Triturate 3.85 grains of lampblack with 3 to 4 drops of gold-size oil in a dish to a homogeneous coherent mass and carefully dilute the latter with 24 drops of oil of turpentine. This mixture is especially suitable for optical instruments. Apply a very thin and uniform coating to the articles by means of a fine brush and allow to dry thoroughly.

Protecting Iron and Steel by Electrolysis.—The methods at present in use for the prevention of oxidation of steel and iron have all the same object, namely, the formation of a coating of magnetic oxide of iron; but all of them are more or less unsatisfactory. Con-

siderable time is usually required, and there is no certainty that the protection will be perfect. M. de Meritens has been experimenting for some time on an electrolytic method of obtaining the same results and has finally been successful. The process is as follows: The article is exposed to a current of electricity in a bath consisting of ordinary water, or, better, of distilled water, heated from 158° to 176° F. The object to be coated is made the anode, while a strip of carbon, copper, or iron serves for the cathode; or, if an iron tank is used, the sides of the tank may form the cathode. The current should only have an electro-motive force slightly in excess of that required to decompose water, as too strong a current produces a pulverulent form of the oxide, which does not properly adhere; moreover, it has the inconvenience of eating into polished surfaces. The operation should be conducted in the same manner as electrotyping. In the course of a few minutes black coloration appears on the article, and after one or two hours the coating of magnetic oxide of iron is of sufficient solidity to resist polishing. The coating is found to penetrate into the mass of the metal; for if the external portion be removed by means of emery, and the white under-surface be again exposed in the bath, it becomes black again almost immediately, demonstrating that the effect of the first electrolyzing has affected the mass to some depth. When a piece of rusty iron is treated by the current in a warm water-bath in the manner described, the rust, consisting of ferric oxide, is completely converted into magnetic oxide. The exterior layers are not adhesive, but the interior coating is almost as hard as the metal itself. The best processes hitherto employed for coating steel goods require at least eight or ten days, and only imperfect results are obtained when applied to wrought or cast iron. De Meritens' process treats all sorts of iron and steel effectually in a few hours, requires no preliminary preparation, and can be applied as easily to rough as to polished surfaces. The coating is a brilliant black, is very hard, and it is difficult to attack it with lime; moreover, it is not easily wetted with water.

Bronze-Colored Coating of Oxide upon Iron.—By the following process iron articles, especially for artistical purposes, can be readily provided with a beautiful bronze-colored coating of oxide, which is quite proof against the influence of moisture, and has the further advantage that every desired bronze color can be produced in a simple manner. Free the articles from grease and, after polishing them, expose them to the vapors of a mixture of concentrated hydrochloric and nitric acid (1 : 1) for two to five minutes. Continue the heating until the bronze color appears upon the articles. After thoroughly rubbing in with vaseline heat again until the vaseline begins to decompose. After cooling the article is again thoroughly rubbed with vaseline. By exposing the iron articles to the vapors of a mixture of concentrated hydrochloric and nitric acid, light red brown shades are obtained. By adding, however, acetic acid to the mixture, and allowing the vapors to act upon the iron, coatings of oxide of a beautiful bronze yellow color may be obtained. By various mixtures of acids coatings of oxide of all possible shades, from dark to light red-brown, from dark brown-yellow to light bronze-yellow may be produced upon iron. In this manner 5-feet long T bars for iron boxes have been coated with such layers of oxide, and though they were exposed for 10 months to the action of the air of a laboratory constantly filled with acid vapors they did not show the slightest alteration.

Coating to Protect Wrought-iron Pipes against Rust.—Mix crude asphalt 28 parts, coal tar free from oily substances 72 parts; or refined asphaltum 16½ parts, coal tar free from oily substances 83½ parts, and boil the mixture until it is of a suitable consistency. If the lacquer does not adhere well or cracks off, the mixture has been either superheated or the tar or asphalt contained too much oily substance.

To Enamel Cast-iron.—The cast-iron utensils are first cleansed with sand and dilute acid, washed and dried. A thin coat of gum arabic solution is then applied with a brush and the finely-powdered enamel scattered upon the layer of gum. The enamel is prepared by fusing together a mixture of 130 parts of pulverized flint glass, 20 parts of calcined soda and 12 parts of borax. The mass thus obtained is powdered when cold. The delicate powder is scattered over the iron vessel coated with gum solution, and the vessels are dried in an oven having a temperature of 212° F. They are then heated in another oven to a red heat, whereby the enamel melts and coats the sides of the vessel with a glass-like coat. The vessel is then cooled in a closed chamber and finally annealed.

Enamelling Masses for Utensils and Sheet-iron.—Silica 30 to 50 parts, flint 10 to 20, China clay 10 to 20, pipe clay 8 to 16, chalk 6 to 10, porcelain ground to a fine powder 5 to 15, boric acid 20 to 40, saltpetre 6 to 10, gypsum 2 to 6; or, quartz 30 to 50 parts, granite 20 to 30, borax 10 to 20, glass 6 to 10, magnesia 10 to 15, feldspar 5 to 20, soda 10 to 20, lime 5 to 15, heavy spar 2 to 8, and fluorspar 3 to 10.

The constituents are ground separately, then mixed, fused, again ground, and the glaze applied as thin as possible. The proportions in which the materials are to be mixed depend on the raw materials themselves and have to be ascertained by determined experiments. A granite which, for instance, is richer in quartz than another variety requires a larger quantity of soda than a variety which contains much fluorspar.

To Color Iron.—1. By placing bright articles of iron in a mixture of a solution of 4 ozs. 15 drachms of sodium hyposulphite in 1 quart of water and one of 1 oz. 3 drachms of acetate of lead in 1 quart of water, and heating gradually to boiling, they acquire an appearance as if blued. 2. By bringing a mixture of 3 parts of sodium hyposulphite and 1 part of acetate of lead in a dissolved state upon bright iron surfaces and heating, a layer of disulphide of iron is deposited, through which shows the metallic surface in various shades of color. 3. By dipping small articles of cast or wrought iron in melted sulphur, to which some soot has been added, a coating of ferric sulphide is formed which acquires a beautiful polish by rubbing.

Coating for Cast-iron.—If cast-iron articles are not to be coated in the ordinary manner with paint, lacquer, etc., but are nevertheless to show a nice appearance, they are first cleansed by washing with a dilute acid and after drying the surface is thoroughly smoothed with a file or wire brush. They are then thoroughly rubbed several times with ordinary crude petroleum, allowing one coat of the oil to dry thoroughly before applying the next. The articles are then brushed with a stiff hair-brush, whereby they acquire a dark lustrous appearance which even remains unchanged on exposure to heat and

afford complete protection against rust. When once the basis for a lustrous appearance is laid in this manner, a simple rubbing over with petroleum and brushing suffices later on, the cast-iron articles acquiring thereby a more intense, dark lustre.

Coloring and Polishing Brass.—In order to prevent the constant oxidizing of brass articles, agents have been for a long time experimented with, to protect the surfaces of these articles against the influence of the atmosphere, and the following method has been proposed as the most suitable and practical one:

If brass is left for some time in moist sand it assumes a very handsome brown color which, if polished with a dry brush, remains constant and requires no cleaning or polishing. A darker or lighter green color may also be imparted if a thin layer of verdigris is created upon the surface by means of dilute acids, which are to be left on until dry. The antique appearance imparted to the brass in this manner is very handsome and more or less durable. But it is not always possible for want of time to do this with each article, and a more rapid method for effecting the end is therefore necessary and the simplest way to do is to cover the brass with a coating of varnish.

All the necessary work is to be done before the bronzing, and the brass is annealed, dipped in old or dilute nitric acid until the scales can be loosened from the surface, which is then treated with sand-water and dried. The next step is to produce the desired bronze. Although this word actually signifies a brown color, being derived from the Italian word *bronzine*, or in English "burned brown," it is rather loosely applied in the trades at present, and applied to all colors. Brown, of all shades, is produced by immersion in a solution of nitrate or chloride of iron, whereby the strength of the bath determines the depth of the color. Olive green, if the surface is blackened by means of a solution of iron and arsenic in muriatic acid; it is then polished with a plumbago brush, and afterwards coated with a lacquer composed of 1 part varnish lacquer, 4 parts turmeric, and 1 part gamboge. A steel gray color is precipitated upon brass by means of a weak boiling solution of arsenic chloride, and a blue by an attentive treatment with a strong sulphide of soda. Black is much used for optical instruments and is produced by painting with a platinum solution, or with chloride of gold mixed with nitrate of tin. The Japanese bronze their brass by boiling it in a solution of sulphate of copper, alum and verdigris.

The success in the art of bronzing chiefly depends upon certain circumstances: For instance, the temperature of the alloy or solution, the proportion and qualities of the materials used for alloying, the proper moment at which the article is to be withdrawn, and a hundred other minutiæ of attention and manipulation require a skill only taught by experience. If the brass is to receive no artificial color, but simply to be protected against tarnishing and oxidizing, it is to be lacquered after having been thoroughly cleansed. In order to prepare the brass for this coating it must be dipped after having been annealed, and, as aforesaid, rinsed and washed for a moment in pure commercial nitric acid until covered with a white coating of the appearance of curdled milk, when the article is taken out, rinsed in clean water, and dried in sawdust.

In the first case the brass becomes lustrous and in the latter mat, which is generally improved by smoothing and polishing in prominent places. The article is then dipped for a moment in nitric acid as

found in commerce, and containing a little crude cream of tartar in order to preserve the color up to the moment of lacquering, and finally dried in warm sawdust. When prepared in such a manner the article is taken in hand to be lacquered, for which purpose it is first to be heated upon a hot plate, to be lacquered afterwards. For this purpose is used a simple alcohol varnish consisting of 1 oz. of shellac dissolved in 1 pint of alcohol. To this simple varnish are to be added the coloring substances, such as sanders wood, dragon's blood and annato, which increases the lustre of the color. In order to moderate the shading of color, turmeric, gamboge, saffron, cape aloes and gum sandarac are added. The first colors make the lacquer reddish, the second yellowish, while the two, when mixed, give a nice orange.

A good pale lacquer consists of 3 parts aloes and 1 part turmeric to 1 part of simple varnish. A gold lacquer is obtained by adding 4 parts dragon's blood and 1 part turmeric to 1 part of simple varnish, while a red lacquer is produced from 32 parts annato and 8 parts dragon's blood to 1 part of the varnish. Lacquers are subject to chemical change by the heat and light and must, therefore, be kept in a dark place. The vessels in which they are stored are generally of glass or clay, and the brushes with which they are applied must be camel hair and have no metallic parts about them.

To Blue Small Sheet-Steel Articles.—Dip the articles into a fluid alloy of 25 parts lead and 1 tin, which melts at the degree of heat required for bluing. The dipping can also be done in a sand-bath heated to and kept at the temperature required (572° F. for dark blue, and 478° F. for pale blue).

Red Stain for Copper Articles.—A brown color may be produced upon copper articles by placing them in a bath composed of 1 part verdigris and 16 parts water, and compounded with ammonia until a clear blue solution is formed. To this bath add further a mixture of 2 parts liver of sulphur, 3 parts spirit of sal-ammoniac, and 10 parts water, shaking the mixture thoroughly before use. To avoid the formation of spots and stains the articles must previously be thoroughly cleansed. By slight heating the color passes into reddish brown and becomes lighter.

To Produce a Silver-white Coating on Brass.—Dissolve 46 parts cream of tartar and 4 tartar emetic in 1000 hot water, add 50 hydrochloric acid, 125 powdered (or fine granulated) tin, and 30 powdered antimony (metal). Heat to boiling and dip into it the objects to be coated. After having been boiled half an hour the brass will have a silver-white, hard, and durable coating.

For Coppering Zinc Plates the following baths are recommended: To coat a zinc plate with a hard but very thin layer of copper, dip it into bath composed of 100 parts of saturated solution of cupric chloride (40 parts of cupric chloride and 60 of water), 150 parts of ammonia and 3000 of water. For very solid coppering add to the bath saturated solution of prussiate of potash until the blue color of the first mixture has quite disappeared. This mode of coppering is somewhat slower than by the galvanic process, but yields equally good results. For plates engraved with the chisel or the cold needle it is best to use a mixture of prussiate of copper with neutral potassium sulphate, to which another mixture of a saturated solution of sulphate of copper in water and water

saturated with prussiate of potash is added. The bath is ready for use when the precipitate is completely dissolved and the fluid discolored. By adding to the above-mentioned reagents sulphate or chloride of zinc a good brass bath is obtained, which is allowed to act upon the zinc plate with the assistance of a single electrical element. Instead of using completely saturated baths one-quarter to one-third of their volume of ordinary water can be added in both cases. For hard coppering the second bath is the most suitable.

Brush Coppering for Iron and Steel.—This process can be recommended for its simplicity and general applicability. The utensils required are two vessels of sufficient size, each provided with a brush preferably so wide that the entire surface of the article to be treated can be coated with one application. One of the vessels contains a strongly saturated solution of caustic soda and the other a strongly saturated solution of cupric sulphate (blue vitriol) of the best quality.

For coppering, the well-cleansed article is first uniformly coated with a brush full of the caustic soda solution and then also uniformly with a brush full of the copper solution. A quite thick film of copper is immediately firmly deposited upon the article. Care must be had not to take the brush too full and not to touch the places, once gone over, the second time, as otherwise the layer of copper does not adhere firmly. The coppering thus produced is so strong and durable that, without fear of injury, the articles can afterwards be scratch-brushed, gilded, and silvered, and also colored brown or steel blue.

For executing the coloration the following directions are given: *For brown*, dissolve 6.77 drachms of calcium monosulphide and 1 oz. 6 drachms of powdered sal-ammoniac in 10 quarts of water. Small articles are dipped into this solution and large ones brushed over with it. After dipping the articles must be thoroughly scratch-brushed, as they show various colors when they come from the bath and acquire a uniform tone only by scratch-brushing.

For *dark steel blue*, dissolve 11.25 drachms to 1 oz. of potassium sulphide and the same quantity of common salt in 10 quarts of water. The bath is used in the same manner as for brown.

Tinning Copper without Heating.—Scrape a quantity of block tin into shavings, put them in a bottle and add a sufficient quantity of mercury to make an amalgam, which is to be shaken and then covered with muriatic acid. The acid will not dissolve the amalgam, but assists in the process of tinning. By taking a portion of the above mixture on a rag and rubbing it on the clean surface of the copper a beautiful but not very durable surface will be the result. When tinning brass with the mixture care is to be taken, as the mercury unites with the zinc, and is apt to destroy the metal. As the mixture contains mercury, which is very poisonous, it would not be safe to use it for tinning culinary articles.

To Zinc Old and New Parts.—It frequently happens that zincked articles exposed to strong wear become damaged. To put such articles into good condition, *i. e.*, to rezinc them, it is first absolutely necessary to subject them to a thorough cleansing. With iron articles the process is as follows: Prepare a pickle from 5.64 to 8.46 drachms of sulphuric acid and 1 quart of water and allow the articles to remain in this bath until the oxide is eaten off; then dip them, but only for a moment, in

strong nitric acid and wash off quickly with much water. To large articles the pickle may be applied with a brush, thoroughly scrubbing afterward with sand. This scrubbing is also necessary when the coating of zinc still adheres to single places or parts of the articles, since the zinc strongly oxidizes in this pickle. Articles of brass or copper are best cleansed with a pickle consisting of equal parts of sulphuric and nitric acids with a small addition of common salt. If the articles are strongly oxidized or oily it is best to previously pickle them and also remove the oil by heating. The pickle for this purpose consists of 1 part sulphuric acid in 8 to 10 water. The articles being thus thoroughly cleaned, they may be rezincked in various ways. Iron is best zincked by dipping into a fluid zinc bath. The articles are first dipped in a concentrated solution of sal-ammoniac, then quickly dried and finally dipped into the melted zinc. If the articles are of large size they must not be too quickly removed from the bath, as otherwise the zinc adheres more firmly to places not yet sufficiently heated than to others. To prevent the articles from cooling off too quickly they must, after being removed from the zinc bath, be placed in hot, preferably boiling water. Small articles are brought into the zinc bath in a net of strong iron wire, and have to be constantly shaken to insure all the places and all the articles being coated with zinc. Copper and brass may also be coated by chemical means, the process being as follows: The articles are dipped into a bath of chloride of zinc solution made boiling hot, and to which a few pieces of granulated zinc are added. By remaining a few minutes in contact with the zinc the articles become coated with a very bright, firmly-adhering layer of zinc. The articles may also be dipped in a solution of zinc dust in concentrated caustic soda lye. This bath must also be brought to the boiling point.

Tinning by Simple Immersion.—Argentine is a name given to tin precipitated by galvanic action from its solution. This material is usually obtained by immersing plates of zinc in a solution of tin containing about 93 grains of the metal to the quart. In this way the tin scrap can be utilized. To apply the argentine according to M. P. Marino's process, a bath is prepared from argentine and acid tartrate of potash rendered soluble by boric acid. Pyrophosphate of soda, chloride of ammonium, or caustic soda may be substituted for the acid tartrate. The bath being prepared, the objects to be coated are plunged therein, first having been suitably pickled and scoured, and then may be subjected to the action of an electric current. But a simple immersion is enough. The bath must be brought to ebullition, and objects of copper or brass, or such as are coated therewith, may be immersed in it.

Electro-plating with Aluminium.—Dissolve 50 parts of potassa alum in 300 parts of water and to this add 10 parts of aluminic chloride. Heat the liquid to 200° F. and after cooling add 39 parts of cyanide of potassium. The object to be plated must be absolutely freed from grease. It is suspended in the bath over the electro-positive electrode, the plate of metallic aluminium being suspended on the negative pole. The electric current ought to be weak. The plating when polished will be found equal to the best silver plating, having the advantage of not being oxidized or getting black from sulphurous vapors.

Electro-plating with Bismuth.—For this purpose the solution of a double chloride of bismuth and ammonia is employed. The operation

takes place in the cold way, the solution containing from 14 drachms to 1 oz. 3 drachms of the chloride per quart. The current is produced by a simple Bunsen element. The articles when taken from the bath are coated with a sort of dark scum through which shines the coat of bismuth. The coating adheres very firmly, its color being a medium between antimony and old silver.

Electro-plating with the Platinum Metals.—The following process has been recommended by Prof. Silvanus P. Thompson. The impure metal is first obtained as a chloride by the ordinary chemical processes. The excess of acid is evaporated off in a water bath, and the salt finally re-dissolved in distilled water and from 10 to 50 times its weight of a solution of sodium phosphate either pure or mixed with borax. The solution is then raised to the boiling point and sal-ammoniac, common salt, or sodium bromide added. The solution is then re-heated and finally neutralized with either the carbonate or, if alkaline, with the bicarbonate of soda. In depositing the metal from a bath of the above solution it should be heated to from 140° to 194° F., and the metal deposited in the ordinary way. In the case of platinum a brilliant deposit can be obtained from a bath of the following composition:

Chloride of platinum	2 parts.
Sodium borate	16 "
Sodium carbonate	16 "
Sal-ammoniac	2 "
Water	150 "

Cheap Mode of Coating Metals with Platinum.—Iron articles are first coated with a mixture of lead borate, cupric oxide and oil of turpentine and exposed to a temperature of from 482° to 642° F., whereby the coating melts and spreads uniformly upon the iron, penetrating its pores. If a smooth surface (enamel-like appearance) is to be given to the objects a second coating of lead borate, plumbic oxide and oil of lavender is applied in the same manner. Upon these coatings a uniform, thin layer of platinum can be readily precipitated by applying by means of a brush (or for smaller articles by dipping) a solution of dry platinum chloride in ether and volatile oils and evaporating the fluid at a temperature not exceeding 392° F. Finely divided platinum is thus separated which adheres firmly to the surface. If the objects were only provided with the first coating the precipitated platinum has a dull color. Such treatment suffices if the coating is only to serve the purpose of protecting the articles from wear and destruction. For decorative effects it is, however, recommended to provide the articles with both the coatings above mentioned. On account of its general applicability and cheapness and the great power of resistance of the coating, this method can be especially recommended for plating articles with platinum on a large scale.

To Unite Nickel, etc., with Platinum.—According to an English patent plates or sheets of nickel or its alloys and of platinum or silver or their alloys are united with each other by placing the thoroughly cleansed surfaces upon each other and subjecting them to the action of heat and pressure. To prevent the access of air the pieces to be united are enclosed in an envelope of sheet iron, sheet copper or other metallic sheet, the adhering of the envelope to the pieces to be joined being

prevented by an intermediate layer of magnesia or lime. Nickel wire may be coated with platinum by wrapping platinum sheet around a nickel core and treating in the manner above stated.

Nickel-plating.—Conditions for the Production of a Beautiful and Durable Coating.—1. Purity of the nickel salts and nickel anodes used; the latter especially are frequently the cause of poor nickelling. They should be free from copper, while a content of iron is not injurious. 2. The anode surface must not be smaller than the metallic surface to be nickelled. 3. The nickel-bath must not be too concentrated; a solution of 1 part nickel salt—best the double sulphate and ammonium—in 18 to 20 parts of distilled water can be especially recommended. The water gradually evaporating must be constantly replaced, and further, the temperature of the bath must not fall below that of an ordinary living room. 4. The bath must not lose its neutral reaction; if acid reaction appears add drop by drop dilute solution of ammonia until neutral reaction reappears. 5. For articles of copper and its alloys special baths have to be prepared, to which for every pound of nickel salt 2.82 drachms of sal-ammoniac must be added. 6. A strong current is required for the production of a light-colored and durable nickelling. The separate operations are executed in succession as follows: 1. Mechanical cleansing of the articles by means of a scratch-brush in case much rust, verdigris, or dirt has to be removed. 2. Treatment with a boiling solution of potash—1 part potash to 10 or 12 water. 3. Rinsing the articles with boiling water. 4. Articles of iron or steel are placed in dilute sulphuric acid, while brass articles are pickled in the usual manner. 5. Careful washing with cold water. 6. The articles thus cleansed are put into the nickel-bath where they remain a shorter or longer time according to the degree of nickelling desired. 7. The nickelled articles are dried in saw-dust. 8. The articles are polished, if desired, upon a felt-disk with the assistance of Vienna chalk or polishing rouge.

The cleansing operations must be executed with special care, and from operation 1 to 7 the articles must not be touched with the hands, as otherwise they will show defective places.

Electro-plating with Nickel.—The following solution for electro-plating with nickel is used by several firms in Hainault: 17.63 ozs. of nickel sulphate, 12 ozs. 14 drachms of neutral ammonium tartrate, 1.41 drachms of tannin dissolved in ether, and 2¾ gallons of water. 1½ quarts of water is first added and the mixture boiled for 15 minutes; the remainder of the water is then added and the whole filtered. The solution yields an even white deposit, which is not brittle, and the cost of which is hardly more than electro-plating with copper.

A new Nickel Bath is composed of 35 ozs. 4.38 drachms of pure nickel sulphate, 26 ozs. 7.28 drachms of neutral ammonium tartrate, 2.82 drachms of tannin, and 5½ gallons of water. The neutral ammonium tartrate is obtained by saturating a solution of tartaric acid with ammonia. The nickel salt must be absolutely neutral. For this purpose dissolve all in 3 to 4 quarts of water and let it boil for about one-quarter hour; then add sufficient water to bring the fluid up to 5½ gallons and filter. By retaining the above-mentioned proportions of the ingredients the bath never undergoes a change. The precipitate obtained is very white, soft, and uniform, and even with a thick deposit the surface shows no roughness, nor does it come off provided the article

had been thoroughly cleaned. Very thick precipitates can be produced upon crude or polished castings at a cost but little exceeding that of coppering.

Nickelling of Tin-lead Alloys.—To solidly nickel articles of tin-lead alloys without previous coppering or brassing, an especially good nickel bath is required. The two following baths can be recommended for the purpose: *Bath A:* Dissolve 7 ozs. of ammonio-sulphide of nickel in 10 quarts of hot distilled water, then add gradually 14 ozs. of nickel carbonate and allow the mixture to boil half an hour. After allowing the mixture to cool to 104° F. neutralize it by the addition of cold solution of citric acid. In nickelling articles of tin-lead alloys the bath must be constantly kept neutral; in case it becomes acid add nickel carbonate; if it is alkaline neutralize it with liquid citric acid. (Acetic acid answers as well and is much cheaper.)

Bath B: Dissolve gradually in 10 quarts of hot distilled water 28 ozs. 12 drachms of ammonia-sulphide of nickel, 5 ozs. 4 drachms of sodium sulphate, and 3 ozs. 8 drachms of ammonium chloride, and allow this bath to boil 15 minutes. Both baths are to be used only when cold. In both baths, each of 50 quarts, the work is executed with a current of three Bunsen elements No. 3, rolled nickel anodes being used. The deposit of nickel in bath A is very hard and takes a high polish, and for this reason the articles must not be allowed to remain too long in the bath, say 15 to 30 minutes, according to the number of articles. The deposit in bath B being less hard, the articles must remain longer in it, and having a duller appearance when taken from the bath require a more careful after-polishing. When using bath B care must be had that the surfaces to be nickelled are always suspended opposite the anode. Bath A can be especially recommended for nickelling on a large scale articles of an alloy of tin and refined lead, though it is somewhat more expensive than bath B. In pickling polished articles wadding is used, but rough places must be cleansed with hot soda lye and the use of a goat-hair brush. Before bringing the articles into the nickel-bath they must be thoroughly rinsed in clean water. The slight film formed upon the articles by pickling exerts no influence upon the nickelling. From bath A the articles come with a beautiful lustre, and they can be polished with ease. In polishing nickelled articles care must be had not to allow them to become too hot as otherwise the nickelling becomes full of cracks.

Nickelling of Polished Articles of Iron and Steel.—The method of coating metallic articles with a thin layer of nickel without the use of a galvanic battery consists in placing the article to be nickelled in a solution of chloride of zinc and nickel salt. As in this method, where the metal comes in contact with zinc, stains may be readily produced, which afterwards would have to be removed by polishing, a special process is used. Bring into a dilute (5 to 10 per cent.) solution of pure chloride of zinc sufficient nickel sulphate to give the fluid an intense green color and then heat to the boiling point, best in a porcelain vessel. Without paying attention to a possible clouding of the fluid by the separation of a basic nickel salt, place the articles previously thoroughly freed from fatty substances, etc., in the bath in such a manner that they do not touch each other, or at least only in a few places. Keep the bath boiling from 30 to 60 minutes, constantly replacing the water lost by evaporation. During this time the nickel precipita es in the

form of a bright lustrous layer wherever the article is free from fat or oxide. When the article is uniformly nickelled it is taken out, washed in water containing some chalk, and then carefully dried. This layer of nickel bears polishing with chalk, and can be recommended for purposes where a firmly adhering but thin coating is desired. The chloride of zinc used must not contain any metal precipitable by iron. Where a good commercial article cannot be had, it is best prepared by dissolving zinc waste in hydrochloric acid and allowing the solution to stand with an excess of zinc for separation of the metals precipitable by zinc. After 24 hours the solution is filtered and is then ready for use, it containing for every part of dissolved metallic zinc 2.1 parts of chloride of zinc. The nickel sulphate used should also be as pure as possible, and the solution, when brought in contact in the cold with bright iron, should not separate a metal, for instance copper, precipitable by iron. Furthermore, during the operation, when in consequence of the formation of a layer of nickel the fluid has acquired a less intense green color, fresh nickel salt must be added until the intensity of the green color is restored. On standing in the air the fluid used for nickelling separates, in consequence of the absorbed iron, ferric hydrate, from which it can be freed by filtering. After the addition of some solution of chloride of zinc and nickel sulphate it can be again used for nickelling. With the use of cobalt sulphate lustrous metallic cobalt can in the same manner be deposited upon polished articles of steel and iron.

To Coat Zinc with Nickel.—For the production of a coating of nickel upon zinc the following solution is recommended as giving good results: The solution is composed of 10 ozs. of the double carbonate of nickel and ammonia, 4 ozs. of ammonium chloride, and 2 ozs. of potassium chloride in a gallon of distilled water. The salts are dissolved in hot water and the bath is used at an ordinary temperature, say 62° F. The zinc must be thoroughly cleansed, rinsed in clear cold water, and brought as quickly as possible into the bath. In using the current, which should have a strength of 17 ampères per square foot of surface, great care must be had that the zinc is inserted before it touches the solution.

To Imitate Nickel Plating.—A sort of light nickel plating is obtained by heating to the boiling point a bath of pure granulated tin, crude tartar and water, and adding a little oxide of nickel heated to a red heat. A brass or copper article immersed in the solution is almost immediately coated with nearly pure nickel. By then adding some carbonate or tartrate of cobalt a bluish coloration is obtained, the depth of which depends on the quantity of the cobalt used. While this method cannot be advantageously used for plating large quantities, it may be profitably used for working on a small scale.

Cold Silver Plating.—Freshly deposited chloride of silver, well washed with hot water, is mixed in equal proportions of table salt and cream of tartar, until it becomes a paste, if necessary, with additions of water. The article to be silvered is first cleansed with a good stiff brush and a solution of soda and soap and thoroughly rinsed to remove any dirt, and again rinsed with hot water. It is to be recommended to submit it to a dry cleaning with pulverized and washed chalk, pumice stone powder, or quartz powder. When well rinsed with cold water,

make a ball of loose cotton wrapped in soft muslin, and with this coat the wet article with a thin layer of salt; then rub some of the silvering paste on to it until the whole article under treatment is well silver-coated. When sufficiently coated, quickly rub with a little ball some cream of tartar upon the silvering, and wash. The silver deposit will be found handsome, clean and white as snow.

Silvering without a Battery.—Silvering by contact is not so durable as by battery, although the color is the same. The solution is prepared as follows: Take 1 part chloride of silver, 6 prussiate of potash, 4 purified potash, 2 salt, 4 caustic ammonia and 4½ rain water. First prepare the chloride of silver, next dissolve the prussiate of potash in water, and add then the potash, salt and ammonia, and boil the whole for ½ an hour in a porcelain vessel; filter and the fluid is ready for silvering. The utmost cleanliness is a primary condition by this method. Heat the fluid up to boiling, then introduce the article, together with a piece of clean zinc. Take it out after a few minutes and brush it with cream of tartar, and put it back again in the solution, in which leave it for 3 or 4 minutes. Then brush again, and continue this until it is sufficiently silvered. This silvering will bear polishing with the steel, and takes a nice lustre. Articles silvered by this method cannot be distinguished from silver articles. It is very good to protect galvanic casts against dimming. But when silvering no more of the fluid must be taken than will be used.

Silvering Iron.—A manufacturer in Vienna employs the following process for silvering iron: He first covers the iron with mercury, and silvers by the galvanic process. By heating to 572° F. the mercury evaporates, and the silver layer is fixed. Ironware is first heated with diluted hydrochloric acid, and then dipped into a solution of nitrate of mercury, being at the same time in communication with the zinc pole of an electric battery, a piece of gas carbon or platinum being used as an anode for the other pole. The metal is soon covered with a layer of quicksilver, and is then taken out and well washed and silvered in a silver solution. To save silver, the wire can first be covered with a layer of tin; 1 part of cream of tartar is dissolved in 8 parts of boiling water, and one or more tin anodes are joined with the carbon pole of a Bunsen element. The zinc pole communicates with a well-cleaned piece of copper, and the battery is made to act until enough tin has deposited on the copper, when this is taken out and the iron ware put in its place. The wire thus covered with tin, chemically pure and silvered, is much cheaper than any other silvered metals.

Powder for Silvering.—To 16 parts melted tin add an equal quantity of mercury; rub it well together and mix with it 125 parts of prepared hartshorn. Any metal rubbed with this will take the appearance of silver.

CELLULOID, RUBBER, ETC.

How Celluloid is Made.—The following is a description of the process carried out in a factory near Paris for the production of celluloid:

A roll of paper is slowly unwound, and at the same time is saturated

with a mixture of 5 parts of sulphuric acid and 2 parts of nitric acid, which falls upon the paper in a fine spray. This changes the cellulose of the paper into pyroxylin (gun cotton). The excess of the acid having been expelled by pressure, the paper is washed with plenty of water until all traces of acid have been removed. It is then reduced to a pulp, and passes on to the bleaching trough. Most of the water having been got rid of by means of a strainer, the pulp is mixed with from 20 to 40 per cent. of its weight of camphor, and the mixture thoroughly triturated under millstones. The necessary coloring having been added in the form of a powder, a second mixing and grinding follows.

The finely divided pulp is then spread out in thin layers on slabs, and from 20 to 25 of these layers are placed in a hydraulic press, separated from one another by some sheets of thick blotting paper, and are subjected to a pressure of 150 atmospheres until all traces of moisture have been got rid of. The matter is then passed between rollers heated to between 140° and 150° F., when it issues in the form of elastic sheets.

Preparation of Celluloid Burning with Difficulty.—The inflammability of celluloid, which has often caused accidents, is prevented or reduced by the addition of protochloride of tin in mixing the celluloid mass. Mix 100 parts of nitrated paper or nitrated cotton with 40 parts of camphor and 70 of protochloride of tin, moisten the mixture with 100 parts of alcohol, and after 12 hours knead it with rolls heated to 140° F. until the mass is thoroughly homogeneous. This mass is said to burn only when brought in direct contact with a flame, and immediately extinguishes, without after-smoldering, when removed from the flame.

Printing upon Celluloid.—To prevent the running of the colors in printing upon celluloid, the coloring substances are dissolved in acetic ether, acetic acid or vinegar essence, which strongly attacks the surface of the celluloid so that the colors immediately penetrate and dry. With some varieties of celluloid this remedy may, however, not prove sufficient. In this case moisten the surface of the celluloid with oil of turpentine or melted turpentine wax.

Mass for Trunk-frames, etc.—Cork meal is intimately mixed with dry curd and lime. The mixture is moistened with water, placed between layers of tissue, and after being intimately connected with the fibres of the tissue by pressure, dried. The plates thus obtained have been patented in Germany under the name of "Suberit-plates." They show considerable solidity and hardness, without being brittle; are very light and can be cut and joined like wood.

To Repair Torn Rubber Belts and Hose.—Fill the previously cleansed breaks with a solution composed of: Gutta-percha, 20 parts; caoutchouc, 40; isinglass, 10; bisulphide of carbon, 160. Very large breaks are covered layerwise with the solution, and after drawing the break together with twine allowed to dry one or two days. The twine is then cut and the cement projecting above the edges removed by means of a sharp knife previously dipped in water.

To Connect Pieces of Rubber.—Dissolve gutta-percha 1 part,

caoutchouc 2 parts in bisulphide of carbon 8 parts. Coat the pieces of rubber with the solution, dry, heat the layers to melting and press the parts to be connected together.

To Make Articles of Rubber Odorless.—Cover both sides of the article with a thin layer of animal charcoal and heat it together with the animal charcoal to from 122° to 140° F. for 3 to 4 hours.

Manufacture of Rubber Type.—The matter or letters to be reproduced are first set up in clean-cut metal type, which is then thoroughly oiled. A rim or guard about half an inch high should then be placed around the form and with a camel's-hair brush a thin cream of plaster of paris is laid over it, to exclude all air bubbles. A thicker paste of plaster is then poured over the form, filling in the guard or the rim up to its edge, and it is then set aside to harden. Alum water is often used to mix the plaster, as this makes a harder mold, but it takes somewhat longer to set. When the mold has thoroughly stiffened, it is removed from the type and placed in a dry, hot place to become well hardened. The mold is now fitted in a frame of suitable size, and a sheet of vulcanized rubber about $\frac{1}{4}$ inch in thickness is adjusted upon it, and the whole is put into a screw-clamp and heated slowly until the rubber becomes soft enough to be forced into the letter spaces of the mold by tightening the screw. The rubber should be allowed to remain in the press at least 24 hours, and until it becomes quite cold. The sheet rubber used for this purpose is usually but slightly vulcanized, having had about 3 per cent. of sulphur kneaded into it with rollers while subjected to a very high temperature. After the impression has been made, therefore, it is necessary to add a greater proportion of sulphur, to insure the required hardness in the type. This is done by immersing the rubber, which has been separated from the mold, in a mixture of 30 parts of bisulphide of carbon and 1 part of chloride of sulphur. This is exposed to a temperature of from 70° to 80° F. until all the bisulphide of carbon has volatilized, and is then immersed in a boiling alkaline solution—made by dissolving 9 ozs. of caustic potash in 1 gallon of water—for a few minutes, and after a subsequent washing in clear, tepid water, is made quite ready for use.

Rubber Stamp Ink.—The usual rubber stamp inks are prepared with water, soluble aniline colors and glycerine. A good formula is given by Dieterich. Aniline blue, soluble in water, 1 B, 3 parts, distilled water 10 parts, pyroligneous acid 10 parts, alcohol 10 parts, glycerine 70 parts. Mix intimately by trituration in a mortar. (The blue should be well rubbed down with the water and the glycerine gradually added. When a solution is effected, the other ingredients are by degrees added.) Other colors are produced by substituting for the blue any one of the following: Methyl violet 3 B, 3 parts; diamond fuchsin I, 2 parts; methyl green, yellowish, 4 parts; Vesuvin B (brown), 5 parts; Nigrosin W (blue-black), 4 parts. If a bright-red ink is required, 3 parts of eosin B B N are used, but the pyroligneous acid must be omitted as this would destroy the eosin. Other aniline colors, when used for stamping ink, require to be acidulated.

CEMENTS, MORTARS, MUCILAGE, PASTE, PLASTER OF PARIS.

A Good Cement for Various Purposes.—Procure a lot of paint, old paint, if possible, from a dealer, the skins forming on top of the paint, settlings from the bottom of paint pots, and, in fact, any refuse which contains oil, zinc, or other mineral body may be used for the purpose.

Reduce this mass, especially if hardened from continued standing exposed to the air, to the consistency of cream by soaking in some cheap oil. Heating may be resorted to if the hard paints cannot otherwise be softened.

When the whole has become soft enough to be stirred into a homogeneous mass, more oil may be added and the whole worked through a sieve and then run through an ordinary paint mill.

A quantity of common whiting is next to be worked into the oil and paint, much in the way as when ordinary putty is to be made. The thickness of this putty, as we may now call it, should not be as dense as when used for glazing.

When the whiting has been thoroughly mixed in and the mass well worked over, add a quantity of good Portland cement, sufficient to bring the putty to consistency which will allow of it being handled readily.

When in this state the putty may be worked into cracks in brick or stone work much as ordinary putty is used when allowed to set and harden, and it will become nearly as hard as iron, impervious to moisture and any reasonable degree of heat.

Roofing Cement.—Mix ordinary red oxide of iron and boiled linseed oil so as to form a paint, add to every quart 1 gill of Japan dryer and then add equal parts of Roman water lime and Venetian red until the mixture is as thick as desired for the work to be done. This cement will be found very useful for flashings or for repairing leaky roofs, as it dries quickly and can be applied by means of a small brush to leaks on a standing seam roof where it would be impossible to solder. It is also useful for repairing cracked seams where the tin has become too rusty to be soldered.

Cement for Repairing Stone Structures.—The repairs of some of the most important stone structures in Paris have been carried out with a cement by Prof. Brune. This is made from 2 parts by weight of oxide of zinc, 2 of crushed limestone, and 1 of crushed grit mixed and ground together into a powder. To this is added a liquid consisting of a saturated solution of zinc chloride, to which is added an amount of ammonium chloride equal to $\frac{1}{6}$ the weight of the zinc contained in the chloride of zinc. The liquid is then diluted with $\frac{2}{3}$ its bulk of water, and 1 lb. of the powder is mixed with $2\frac{1}{2}$ pints of the above liquid.

Cement for Bisque.—Burn some oyster shells, reduce to a powder in a muller and pass through a fine sieve. Make this into a paste with white of egg. The shells should be thoroughly cleaned, well-burned, air-slaked and finely powdered, making simply a fine article of lime.

The parts joined must be held firmly together for two minutes or so after the cement has been applied. Be sure the parts are thoroughly clean before joining.

Very Adhesive Cement.—A cement particularly useful for fastening the brass mountings on glass lamps, as it is unaffected by petroleum, is prepared by boiling 3 parts of resin with 1 part of caustic soda and 5 parts of water, thus making a kind of soap, which is mixed with one-half its weight of plaster of paris. Zinc white, white lead or precipitated chalk may be used instead of the plaster, but when they are used the cement will be longer in hardening.

To Fasten Leather to Cast-Iron.—Spread over the metal a thin, hot solution of good glue; soak the leather with a warm solution of gall nuts before placing on the metal, and leave to dry under an equally distributed pressure. It is claimed that when fastened in this manner it is impossible to separate the leather from the metal without tearing it.

Cement from Chloride of Zinc.—Mix 1 part of very fine glass powder with 3 parts of strongly glowed zinc oxide and keep the mixture in a bottle. On the other hand, dissolve 1 part of borax in as little water as possible, mix the solution with one of chloride of zinc of 1.5 or 1.6 specific gravity, and keep this solution also in a bottle.

For use mix 1 part of the powder with sufficient of the solution to form a paste which in a short time becomes solid and hard as marble. This cement is much used for filling hollow teeth, but is also well adapted for numerous other purposes, such as making air-tight and water-proof connections on apparatus, etc.

Cement to Fasten Porcelain Letters.—Mix 80 parts of starch and 100 of pulverized chalk with equal parts of water and alcohol, together with the addition of 30 parts of Venetian turpentine. Care must be had to agitate the mass with a stick so as to insure its homogeneity.

Flexible Cement is made by melting together equal parts gutta-percha and white pine pitch. This cement softens on the water-bath and is not deteriorated by remelting.

Cement for Mending Valuable Glassware.—Mix 5 parts of gelatine with 1 part of a solution of acid chromate of lime. Cover the broken edges with the cement, press the parts together and expose to sunlight. The light hardens the cement, which will then withstand boiling water.

Cement for Glass and Brass.—Brass letters may be securely fastened on glass panes with a cement composed of, litharge 2 parts, white lead 1, boiled linseed oil 3, gum copal 1. Mix just before using. It forms a quickly drying and secure cement.

Cement for Rendering Water-tight the Joints of Wooden Casks, Cisterns, etc.—Melt 1 lb. of glue with the least quantity of water and then mix it with 1 lb. black resin and 4 ozs. of red ochre. This composition will dry in 48 hours after being applied and will not

only be found useful for these purposes, but may be advantageously employed to fix stones in frames.

Cement for Filling out Holes, Joints and Cracks in Window-frames.—In making window-frames small imperfections due to the constitution of the wood, such as knot-holes, cracks, etc., are frequently observed which cannot be readily repaired with wood, but must be filled up as otherwise they would mar the appearance of the finished work. A cement especially suitable for this purpose and also for filling up such imperfections in window-frames already in use is prepared as follows:

Glow strongly in an iron crucible ochre as finely elutriated as possible. When the crucible is cool take the ochre out and rub it to a uniform powder, which is used as follows: In a sufficiently large iron crucible melt 1 lb. of colophony, and, when liquid, stir into it 1 lb. of thick turpentine. When a clear fluid is formed mix with it 2 lbs. of the above-mentioned burnt ochre. Keep the mixture warm in the crucible and fill up with it the imperfections in the wood; care should be had to previously dry the wood as much as possible in a suitable manner. The mass becomes hard as stone; an excess can be readily removed with a chisel and again used.

Cement for Repairing Defective Zinc Ornaments.—By intimately stirring together to a thick plastic mass a solution of soda water-glass of 33° B. with fine whiting and adding zinc dust (zinc gray), a gray mass is obtained which hardens in 6 to 8 hours, and becomes extraordinarily solid. By polishing it, after hardening, with an agate it acquires the lustrous white color of metallic zinc. It is especially suitable for repairing zinc ornaments and vessels, but it also adheres firmly to stone and wood as well as to metals and glass.

New Cement for Bake-ovens.—To cement holes in bake-ovens the following cheap and durable mass is recommended: Dust of fire-bricks, glass pots or seggars, 2 lbs.; fat clay, 2 lbs.; pulverized pitch, ½ lb., and common salt, ¼ lb. Dissolve the whole in hot water and work thoroughly together to a thin paste. Before pouring it into the holes cool the latter off with water.

Metal Cement.—For the restoration of the colonnades of the Louvre, Brune used the following cement consisting of a powder and a fluid: Oxide of zinc, 2 parts; comminuted hard limestone, 2 parts, and fine sand, 1 part, are mixed and eventually colored with ochre. The fluid consists of a solution of zinc in hydrochloric acid (impure) to which is added ⅙ of the dissolved zinc of sal-ammonia. For use 1 lb. of the powder is mixed with 2½ pints of the fluid. The mixture congeals rapidly to a solid mass.

Cement for Filling Brass and Zinc Signs.—Mix asphalt, shellac and lampblack in about equal proportions, or black sealing-wax may be used. Apply by heating the plate and melting the cement in and evening the surfaces with a warm iron. Then carefully scrape off the excess and hold a hot iron over the letters to glaze the surface.

To Reunite Broken Belting.—Broken belting can be reunited by the use of chrome glue. With a lap of 4 or 5 inches the reunited part is apparently as firm as any part of the band, though it is well to take

the precaution to tack down the ends of the lapped pieces with a few stitches of stout thread. The chrome glue is prepared as follows: Take 100 parts of glue and soak it 12 hours in water; then pour off the surplus water, melt the glue, add 2 per cent. of glycerine and 3 per cent. of red chromate of potash, melting them with the glue. This mixture, thinned by warming, is applied to the lapped ends after having been roughened with a rasp and then placed between two hard wood strips in a vice and well pressed. They should be left 24 hours in the vice to become thoroughly dried.

Stratena.—This well-known cement is said to be prepared as follows: On the one hand 12 parts of white glue are dissolved in 16 parts of acetic acid, and, on the other, 2 parts of French gelatine in 15 parts of water. The solutions are mixed, compounded with 2 parts of shellac varnish and brought into small bottles.

Glue for Damp Places.—Take of the best and strongest glue enough to make a pint when melted. Soak this until soft. Pour off the water as in ordinary glue making and add a little water if the glue is likely to be too thick. When melted, add 3 tablespoonfuls of boiled linseed oil. Stir frequently and keep up the heat until the oil disappears, which may take the whole day and perhaps more. If necessary add water to make up for that lost by evaporation. When no more oil is seen, a tablespoonful of whiting is added and thoroughly incorporated with the glue.

Moisture-Resisting Glue.—A glue which is proof against moisture may be made by dissolving 16 ozs. of glue in 3 pints of skim milk. If a stronger glue is wanted, add powdered lime.

Roman Mortar.—The famous Roman mortar, which has stood the test of use better than any other known to man, was, according to D'Avigdor, prepared with great care, and composed as follows: One part slaked (rich) lime; 1 part brickdust (known in India as Toorkee, and used there for the same purpose) and 2 parts clear river sand. If quarry or pit sand was to be had (which they preferred) 3 parts of the latter were substituted. The care used in storing the sand, lime and brickdust far exceeded the precautions now taken by the most strict of engineers. They excavated immense pits, lined them with masonry and erected a roof, or even a vault over them. Here the sand after being screened was secured from the weather. The lime was specified to be slaked a year before using. It was spread out in large sheds, and the slaking was carried on by the influence of the air, almost without any admixture of water. When hydraulic mortar was required, the Romans substituted puzzolana for the brickdust. This was carefully screened and kept dry; in short, the mortar makers of ancient Rome, who never did anything all their lives but mix mortar, went through their work with such care and accuracy that we should now require a chemical laboratory to do as well.

Making Mortar.—Mortar made in the following manner will stand if used in almost any sort of weather. One bushel of unslaked lime, 3 bushels of sharp sand; mix 1 lb. of alum with 1 pint of linseed oil, and thoroughly mix this with the mortar when making it and use hot. The alum will counteract the action of frost on the mortar.

French Concrete.—A kind of concrete, hard and solid, is now being used for building purposes in Paris. It is composed of sand and gravel, 8 parts; common earth burnt and powdered, 1 part; burnt cinders, 1 part, and unslaked hydraulic lime, 1½ parts. These materials are thoroughly beaten up together, their mixture giving a concrete which sets almost immediately, and in a few days becomes extremely hard and solid.

To Change Quick-setting Cement into Slow-setting.—Mix the cement with ½ to 2 per cent. of a hygroscopic salt (calcium chloride, magnesium chloride, or a mixture of salts which contains these substances as essential constituents) and then grind the whole.

Plastering Outside Brick-walls.—Slaked lime, 60 parts; sand, 35; litharge, 3. Knead and work the ingredients into a stiff mass with 7 to 10 parts of linseed oil; use old oil or linseed oil varnish. It should be well worked to the consistency required and applied as other mortars, well troweled down. Or, sand, 90 parts; litharge, 5; plaster of Paris, 5, moistened and worked together with a small proportion of linseed oil. Oil the brick three coats before applying the mortar and trowel down.

Mucilage for Attaching Labels to Tin.—Among others, the following methods have been suggested for this purpose: The addition of about 3 or 4 per cent. aluminium sulphate (not alum), or better still, about 10 per cent. of butter of antimony, is said to greatly improve the adhesiveness of mucilage. Others have suggested roughening the surface with acids or adding substances to the mucilage which yield acids in small degree on applying to the tin; thus, honey, flour, treacle, etc., have come into use as seen in formula No. 1.

1. Make gum tragacanth into mucilage of the desired consistency with hot water and then add to it 10 per cent. of flour.
2. Boil 2 lbs. of flour with 1 quart of water to make a stiff paste; add 2 ozs. of tartaric acid and 1 pint of molasses. Boil together until stiff and add 10 drops of carbolic acid.
3. Shellac, 2 parts; borax, 1 part; water, 16 parts, are boiled together until the shellac dissolves.
4. Add 1 oz. of dammar varnish to 4 ozs. of tragacanth paste.
5. Roughen the surface with emery paper, then apply the label preferably with water-glass as an adhesive agent.
6. Balsam of fir, 1 part; turpentine, 3 parts. Dissolve. This is only applicable with good qualities of well-sized labels.
7. Clean the surface by rubbing with solution of caustic potash, and then thoroughly wipe before applying the label. This is employed on the principle of attributing the difficulty to the presence of a thin film of grease, as is also the case with the addition of water of ammonia to the paste.
8. Brush the surface over with a thin streak of butter of antimony or with oleate of mercury, clean well and apply the label.
9. Brush over with strong tannin solution, allow to dry and apply the label, previously well gummed.
10. Add Venice turpentine to good starch paste.
11. Soften glue with water and then dissolve it in acetic acid to 10 per cent. strength.

12. About 15 per cent. of glycerine added to the paste is said to work admirably.

Elastic Mucilage.—Dissolve 1 part of salicylic acid in 20 parts of alcohol, add 3 parts of soft soap and 3 parts of glycerine. Shake thoroughly and add the mixture to a mucilage prepared from 93 parts of gum arabic and the requisite amount of water (about 180 parts). This mucilage keeps well, and, when it dries, remains elastic without tendency to cracking.

Preparation of Dextrin Solution for Gumming.—Pour ½ pint of cold water over 2 lbs. of dextrin and stir the mass vigorously for about 10 minutes. The dextrin being thoroughly saturated with water place it in a vessel over the fire, and allow it to remain with constant stirring for about 5 minutes until the mass is reduced to a milky substance. This condition takes place when small bubbles appear on the surface as if the solution would begin to boil. As the solution must not be allowed to boil, it is at once removed from the fire, poured into a wide dish and allowed to cool. When cool add to every quart about 1.75 oz. of glycerine and the paste is ready for use. If too thick dilute with water previously boiled and allowed to cool, since the paste if diluted with ordinary cold water in a short time acquires a bad odor. The paste prepared in this manner has a slightly yellow tint, shows great lustre after drying and does not become brittle.

Paste for Manufacturers of Paper Bags.—A paste prepared from pure wheat starch and a few per cent. of turpentine is very tenacious. Stir the starch with cold water to a homogeneous mass of the consistency of syrup, and then pour over it, with constant stirring, actually boiling water (not only hot) in a thin jet until the paste has acquired a suitable consistency. To 1 part of wheat starch are added 8 to 10 parts of water according to the desired stiffness of the paste, and in order to obtain homogeneity the finished paste has to be stirred until half cold. Then liquefy in a suitable vessel previously heated about 2 to 5 per cent. of the paste of Venetian or ordinary turpentine, and rub it with a portion of the still warm paste until a sort of emulsion is formed. Then mix the whole and work it thoroughly together.

Paste for Fastening Paper upon Tin-foil, etc.—Dissolve rye-flour in a solution of caustic soda to a paste, and dilute the latter with well-water, stirring constantly. Then heat Venetian turpentine and add this to the paste, a few drops being sufficient for ½ lb. of flour. This paste adheres firmly to all metals, tin-foil, glass, etc.

Paste Suitable for Preserving the Gloss of Patent Leather and Preventing Cracking, is made of wax, with a little olive oil, lard and oil of turpentine, mixed when warm, and when cooled should be of the consistency of thick paste.

New Method of Hardening and Coloring Plaster of Paris.—Mix 6 parts of plaster of paris and 1 part of slaked lime previously passed through a fine sieve. Use the mixture in the usual manner, and later on, when the layer of plaster of paris is perfectly dry, saturate it with a solution of any sulphate whose basis is precipitated in an

insoluble state by lime; for instance, the sulphate of iron or of zinc. With the use of sulphate of zinc the mass remains white, while with that of sulphate of iron it acquires a rust-color. The strength of the plaster of paris thus treated surpasses that of the ordinary article nearly twenty times, and it is indifferent to atmospheric influences. Plaster of paris with an addition of $\frac{1}{6}$ lime and saturated with sulphate of iron especially possesses advantageous features. By coating such plaster of paris with linseed oil boiled with oxide of lead, and somewhat browned by heating, the surface acquires the appearance of mahogany, and by the application of a coat of hard copal lacquer the color becomes very beautiful. In this manner an excellent floor-covering may be prepared. Spread a layer 0.23 to 0.27 inch deep of the mixture of plaster of paris and lime upon the floor, and when completely dry, treat it as above stated, with sulphate of iron, then with linseed oil and finally with copal lacquer.

Marble Imitation.—Figures of plaster of paris can be made to look like alabaster by giving them a coat of white dammar varnish, and dusting with powdered glass. If the objects be varnished a second time and coarsely powdered glass or mica be dusted on, a marble-like appearance is produced.

FIRE-EXTINGUISHING AND FIRE-PROOFING MEDIUMS.

Fire-extinguishing Agents.—The *Munich* fire-extinguishing agent consists of common salt, 43 per cent.; alum, 19.5; Glauber's salt, 5; soda, 3.5; water-glass, 6.6; and water, 22.3.

The *Vienna* fire-extinguishing agent is a solution of 4 parts of ferrous sulphate (copperas) and 16 of ammonium sulphate in 100 of water.

Other highly recommended mixtures are as follows: 1. Alum, 30 per cent.; ammonium sulphate, 65; and ferrous sulphate, 5. 2. Boric acid, 20 parts by weight; alum, 30; ferrous sulphate, 25, are dissolved in 200 of hot water, and the solution is then slowly poured with constant stirring into a cold solution of sodium hyposulphite, 30 parts by weight; water-glass, 50; and water, 800.

Johnstone's Fire-extinguishing Agent.—A mixture of equal parts of potassium chlorate, potassium nitrate and pyrolusite (manganese dioxide) is moistened with water-glass and pressed into a block. This block is placed in a paste-board box, and several such boxes connected by fuses are suspended to the ceiling of the room.

Hand Granades for Extinguishing Fire are thin-walled, spherical bottles of blue-glass filled with a solution of calcium chloride, sal-ammoniac or borax. When thrown the bottles break and the fluid contained in them incrusts the burning object with a more or less glass-like layer according to its greater or less concentration.

Fire-proofing Mediums.—Painting buildings with asbestos has become customary in London, and the fire insurance companies of that city have lowered the premiums one-half on structures so treated.

Experiments made in the Champ de Mars, Paris, in trying to burn houses painted with it have shown that it is eminently useful for this purpose.

By the employment of asbestos Nagel has produced an entirely incombustible paste-board in the following manner: A thin paste is made from 200 parts of oxide of zinc and 100 parts pulverized asbestos; this is spread out upon a metallic web. The mass is rolled, and after drying the plate is saturated with a strong solution of chloride of zinc, after which it is passed through the rollers a second time. By this treatment oxychloride of zinc is produced. The moisture causes the formation of a little rust upon the iron wire, by reason of which the substance adheres firmly. The plate is again dried and another time saturated with chloride of zinc; the whole is left in this state so that oxychloride may form, after which the plate is immersed in water for one or two days, whereby all the acid is removed. The plate is then washed and thereby receives its desired flexibility. Such plates, manufactured in this manner, will absorb water, but may be made impermeable by saturating them with a silicate and caseine.

These plates may also be prepared in another manner. Nagle has, for instance, replaced the chloride of zinc by other metallic chlorides and sulphate of aluminia. In place of the oxide of zinc, magnesia, lime and gypsum may be used. For the covering of roofs, plates of the last-named material have been made impermeable by an addition of soap, whereby an insoluble combination of the fatty acids with lime and alumina is formed. Plates prepared according to Nagel's formula will protect wood against danger of injury by fire, as was proved by the following experiment: A box 2.36 inches long, 1.58 inches broad and 1.18 inches high, and only 0.20 inch thick made of plates of this kind, was placed for 5 minutes between the flames of two Bunsen burners without any damage; a paper enclosed within it had not even turned brown.

Asbestos is also a constituent of a colored coating prepared by Wendt and Herad; its composition is as follows: Color (oxide of lead, copper or manganese) 15 parts; linseed oil, 12; silicate of soda, 50; asbestos, talc and kaoline, 15; water, 8.

These inventors have also indicated the following two compositions which contain no asbestos: 1. Water, 75.25 parts; sal-ammoniac, 8; hyposulphite of soda, 2.25; sulphate of ammonia, 10; borax, 4.5. 2. Water, 70.5 parts; hyposulphite of soda, 2.5; sulphate of potash, 10; borax, 5; alum, 12. The latter preparation is by them recommended for the saturation of wood.

Rabitz has specified the following method for rendering walls and ceilings fire-proof: A tightly stretched metallic web is plastered upon each side with a mixture of gypsum, lime and coarse sand, and cow's hair. For the walls make the plates from 1½ to 2 inches thick; for ceiling from 1.18 to 1.38 inches thick; for vaults from 2 to 3 inches thick. The walls will be dry in the course of a few days, after which they may be painted or papered. The plastering of the composition above given may also be replaced by a water-proof cement. Rabitz's method possesses a triple advantage: it protects against fire, moisture and shaking of the earth.

The following coating for textile fabrics, wood and paper is recommended as being incombustible: Boil holly-wood (*Ilex aquifolium*) for one hour in a solution of table salt; to this add sulphate of zinc, sal-ammoniac and alum. The mixture must be heated for four hours

over a gentle fire, then add whalebone and stir so as to incorporate very intimately; the fluid is thereupon passed through a fine sieve. When to be used, it is applied with a paint brush to the object to be protected. Two coats are sufficient for paper or textile fabrics. Evaporation of this fluid when stored can be prevented by keeping upon it a thin coat of gelatine solution.

A water-glass solution can be prepared and used in the following manner: Melt in a crucible 15 parts quartz or very clean sand, 10 parts purified commercial potash, and 1 part charcoal; these several ingredients to be in a powdered state. When the mixture runs steady, pour out. The solidified glass is powdered and dissolved in four to five-fold its weight of boiling water. The solution may be applied with a painter's brush; it dries rapidly, and the coating keeps without change.

Painting with caseine colors, which is for the purpose of producing fireproof coatings, is done in the following manner: Stir together 3 parts of fresh curds and 1 part slaked fat lime. For pigments add earthy or metallic oxides (peroxide of iron for light red to deep brown, ultramarine or cobalt for blue, oxide of zinc or baryta white for white, bone black for black), but no organic dye-stuff, like aniline colors. White lead, Prussian blue, cinnabar and ochre are also unsuitable, as they first lose their color and then turn black. The caseine lime must be prepared on the day on which it is to be used, and the brushes must be cleaned each time after using. Painting with caseine paints is good both for woodwork and masonry.

A solution of table-salt and alum, or water-glass and carbonate of soda, may also be used as a fireproof paint. The aqua-ammonia of gas-houses diluted with water also possesses fire-quenching properties. This fluid is objectionable, however, on account of the suffocating gases it evolves.

Rendering Textiles Fireproof.—Dr. Doremus recommends phosphate of ammonia as a highly effective agent in rendering textiles uninflammable. The fabrics are dipped in a watery solution of the salt, wrung out and dried, when, it is said, they will be found completely uninflammable. They will blacken, of course, and be destroyed where the flame touches them, but the flame will not spread, neither will there be any residue of red-hot cinders.

Preparation of Fireproof Crucibles, Bricks, Etc.—Mix 30 parts of fragments of very refractory fire-clay, 20 parts of pulverized glass, and 5 parts of crude sulphur. Heat the mass until it forms a paste. Then add 25 parts of comminuted asbestos and burn the mass in moulds lined with asbestos. To increase the refractoriness, the quantity of asbestos may be increased and that of the other constituents decreased.

Fireproof Material for Nozzles, Etc.—Mix fire-clay or ganister or both substances with 15 to 20 per cent. of graphite, form the mixture into plugs, nozzles, and other articles used in the manufacture of steel, and burn in the usual manner.

GLASS, PORCELAIN, ETC.

Frosted Glass.—*Verre givre*, or hoarfrost glass, is an article made in Paris, so called from the pattern upon it, which resembles the feathery forms traced by frost on the inside of windows in cold weather. The process of making the glass is simple.

The surface is first ground either by the sand blast or the ordinary method, and is then covered with a sort of varnish. On being dried, either in the sun or by artificial heat, the varnish contracts strongly, taking with it the particles of glass to which it adheres; and as the contraction takes place along definite lines, the pattern produced by the removal of the particles of glass resembles very closely the branching crystals of frost-work.

A single coat gives a small delicate effect, while a thick film, formed by putting on two, three or more coats, contracts so vigorously as to produce a large and bold design. By using colored glass, a pattern in half-tint may be made on the colored ground, and after decorating white glass, the back may be silvered or gilded.

New Method of Deadening and Graining Glass and Mirror Plates.—Coat the places which are not to be affected by the acid with varnish. For deadening place the respective plates vertically in the mixture, and for graining horizontally one upon the other. In the latter case the plates are separated by small wooden or metallic blocks. The mixture consists of a completely saturated solution of soda or potash in hydrofluoric acid. Add four or five times its weight of water to the mixture and then 1 quart of acetic acid to every 30 or 40 quarts of fluid. The coating of varnish can, after the operation, be readily removed by dipping the glass into water saturated with potash and ammonia or into bisulphide of carbon.

To File Glass Utensils.—Dip the file in strong caustic soda lye, and then, while still wet, into coarse sand. With a file thus prepared glass utensils can be worked without cracking the glass.

Cutting Glass by Electricity.—The large cylinders of window glass are encircled with a fine wire, the extremities of which are put in connection with a small electric battery. It is necessary that the wire adhere closely to the glass. When the current of electricity is passed through the wire it becomes red hot and heats the glass beneath it. Then a single drop of water deposited on the heated place will cause a clean breakage of the glass clear around in the path of the wire. Contrary to what takes place with the usual process in the treatment of this fragile material, it is found that the thicker the sides of the cylinder the better the cut.

To Drill Glass.—In drilling glass stick a piece of stiff clay or putty on the part where you wish to make the hole. Make a hole in the putty the size you want the hole, reaching to the glass of course. Into this hole pour a little molten lead, when, unless it is very thick glass, the piece will immediately drop out.

To Drill Majolica and Porcelain.—Ceramic objects can be readily drilled with steel tools. The best tool for drilling through glaze or a

glass body is an ordinary scriber diamond, hardened and moistened with oil of turpentine when used. With majolica and porcelain without glaze it is best to drill under water; for instance, filling the vessel with water and placing it in another vessel filled with water so that the drill is used under water and passes again into water after penetrating the ceramic object. Instead of filling glazed articles with water a piece of cork may be placed on the point where the drill is to pass through. The pressure applied to the drill varies according to the hardness of the material; it must, however, gradually decrease as the drill approaches the point of exit on the other side, and finally cease altogether in order to avoid splintering. For enlarging small holes already existing it is best to use three-cornered or four-square broaches, ground smooth, in the same manner as above described (under water); for hard material, such as glass and glaze, moisten the broach with oil of turpentine. The simultaneous use of oil of turpentine and water is best in all cases, and especially when the object to be drilled does not permit the sole use of the oil as is the case with majolica and unglazed porcelain, which absorb the oil without water being used.

Pencil for Writing on Glass, Etc.—The pencils introduced for writing upon glass, porcelain, and metals in red, white, and blue, are made by melting together spermaceti 4 parts, tallow 3, and wax 2, and coloring the mixture with white lead, red lead, or Prussian blue, as desired.

Electroplating Glass and Porcelain.—The chief difficulty hitherto experienced in the electroplating of glass and porcelain has been to obtain a conducting surface which would not prevent the proper adherence of the metallic coating. M. Hansen uses chloride of gold or of platinum, dissolved in sulphuric ether, to which sulphur dissolved in some heavy oil is added. This compound after having been slightly heated possesses sufficient consistency to allow of a film being laid on the glass with a brush. The object treated in this way is then moderately heated in a muffle until the sulphur and chloride are completely volatilized, the gold or platinum adhering firmly to the surface. The best copper bath is two parts of sulphate of copper to three of distilled water. In silver-plating, seventeen parts of nitrate of silver and thirteen parts of cyanide of potassium dissolved in three hundred parts of water are used. For gold-plating, seven parts of gold are used which are preferably dissolved in *aqua regia*, and precipitated by means of ammonia. This precipitate, while still wet, is then placed in a warm solution consisting of nine parts of cyanide of potassium and ninety parts of water.

To Perforate Earthen Vessels.—Instead of the drill a stick of soft copper and a mixture of emery powder with linseed oil is used in the turning-lathe. In consequence of the friction the emery adheres closely to the copper, and in a few minutes effects the perforation of the hardest materials.

LACQUERS, PAINTS, VARNISHES, ETC.

Aluminium Palmitate.—Aluminium palmitate, a combination of alumina and palmitic acid, is a resinous substance of remarkable prop-

erties, making it useful for many purposes, but especially for the manufacture of lacquer. It melts at a higher temperature than dammar and copal resin, and is easily soluble in oil of turpentine and benzine. The simplest method of preparing the palmitate is as follows: Boil good palm-oil soap or tallow soap in rain water until a clear solution is obtained, and filter the hot solution through several close cloths. Now heat the solution again and dilute with an equal volume of rain water. Then add a boiling hot solution of alum (commercial alum cake) as long as a precipitate is formed. This precipitate is allowed to settle, the supernatant fluid is then poured off, and the precipitate washed several times with boiling water. The precipitate is then dried and heated in a pot standing in a vessel filled with boiling water until it becomes transparent. To prepare lacquer, heat oil of turpentine in a pot nearly to the boiling point, and add a sufficient quantity of the aluminium palmitate to form a solution of the consistency of thick varnish. Should this prove too viscid when cold, it can be readily reduced by adding hot oil of turpentine.

Articles coated with this lacquer should be placed near a hot stove so that they will dry quickly. Palmitate lacquer is of value in manufacturing gold papers and for coating genuine and imitation leather hangings, giving to the latter the characteristic gloss of stamped letter, and preserving it in the first. It furnishes also an excellent vegetable glue which does not spoil, is and remains entirely neutral, and consequently exerts no injurious influence upon the shades of the colors. This makes it especially useful in the manufacture of velvet wall-papers. If used as a sizing on cotton fabrics, it imparts to them a silky gloss, which does not entirely disappear even after frequent washings. This sizing on account of its neutrality and entire indifference can be used for fabrics printed with the most critical colors without injuring them in the least. Palmitate lacquer is not acted upon by water, and as it is perfectly flexible, can, therefore, be advantageously used in the manufacture of artificial leather, rubber tissues and waterproof fabrics; its property of being entirely inodorous when dry deserving special commendation.

Iron Palmitate Varnish for Water-proofing Paper, Tissues, etc.—Dissolve sulphate of iron (green vitriol) in water, and add filtered solution of palm oil soap or tallow soap as long as a precipitate is formed. The precipitate, which now represents an iron soap, is taken out, dried and dissolved in benzine so as to form a solution of the consistency of varnish.

Zapon, a New Lacquer.—This lacquer is manufactured by the Frederick Crane Chemical Co., Short Hills, N. J. It represents a clear, almost colorless, thickish fluid of the consistency of collodion, and smells somewhat like fruit ether. It consists essentially of a solution of celluloid in a mixture of amyl acetate and aceton. Of the last two bodies the "thinning fluid," accompanying the preparation, also consists. The superiority of this product is due to the favorable properties of the celluloid. The transparent, colorless coat obtained with zapon can be bent with the metallic sheet to which it has been applied without cracking. It is so hard that it can scarcely be scratched with the finger-nail, shows no trace of stickiness, and is perfectly homogeneous even on the edges. This favorable behavior is very likely due to the slow evaporation of the solvent, and the fact that the lacquer quickly forms a

thickish, tenacious layer, which though moved with difficulty is not entirely immobile. Another advantage of zapon—especially as regards metallic articles—is that the coating in consequence of its physical constitution preserves the character of the basis. In accordance with the nature of celluloid the coating is not sensibly affected by ordinary differences in temperature, and does not in the course of time become dull and non-transparent, as is the case with resins, in consequence of the loss of molecular coherence. It can be washed with soap and water, and protects metals coated with it from the action of the atmosphere. Zapon may also be colored, but, of course, only with coloring substances (mostly aniline colors) which are soluble in the solvent used for the celluloid. Dipping the articles in zapon being more advantageous than painting, the manufacturers have constructed a special dipping apparatus.

Mattolein or Dull (matt) Lacquer.—Dissolve 18 parts of sandarac and 4 of mastic in 192 parts of ether, and add 48 to 144 parts of benzine. The more benzine the coarser the grain of the lacquer.

Preparation of Resin Pigments.—For the manufacture of the so-called resin pigments, prepare first a solution of resin soap by boiling for one hour, with constant stirring, 100 parts by weight of pale colophony with 10 of dry, 96 per cent. caustic soda, 33 of crystallized carbonate of soda and 1000 of water, and then cooling the solution to about 112° F. by a further addition of 1000 parts of water. According to the desired intensity of the color, add to this soap 5 to 15 per cent. of the weight of the resin used, of the filtered solution of a basic aniline color—fuchsin, methyl—violet, brilliant green, safranin, chrysoidin, auramin, methyl blue, rhodamin. The alkaline-color mixture thus prepared is then compounded, with constant stirring, with small portions of a dilute aqueous solution of a metallic salt—for the above-mentioned quantity of resin about 55 parts of sulphate of zinc in 1000 of water—until precipitation is complete. A slight excess of the metallic salt facilitates the subsequent filtering and washing. The precipitate is carefully washed upon filtering cloths, or by means of filtering presses, whereby hard cakes with a content of 18 to 25 per cent. of resin pigment are obtained, which are dried at as high a temperature as possible, 104° to 112° F. as a general rule, but for magnesium precipitates at 158° F.

The resin pigments are soluble in alcohol; in benzol and its homologues, further in ether, chloroform, acetal and many volatile oils they dissolve, in a dry state, in the proportion of 1 : 1, and form with them, according to the quantity of solvent, more or less thickly fluid varnishes which upon a smooth surface quickly dry to a lustrous, hard, transparent, colored coating. The precipitates are further readily soluble in varnishes prepared with alcohol, benzine, or oil of turpentine, in melting wax, resins, palmitic, stearic, and aleic acids, and their homologues, in rancid oils, and boiled linseed oil. Their solubility decreases with a higher content of coloring matter, which should not exceed 20 per cent. of the weight of resin. In oil of turpentine they are entirely insoluble.

By the addition of solutions of caoutchouc and gutta-percha the elasticity and durability of the varnishes are essentially increased. An especially good composition is as follows, which can be used either by itself or as an addition to other varnishes: Dissolve 30 parts of

magnesium resin pigment in 80 of benzol, and 20 of chloroform, and mix with it 150 parts of a 1½ per cent. solution of caoutchouc in bisulphide of carbon and benzol, previously clarified by heating.

Such varnishes are especially suitable for decorating lustrous metallic surfaces (tin-foil), wood, paper, leather, glass. On account of their cheapness and resistance to the influence of light the metallic resinates of iron, chromium, copper, manganese in combination with Bismarck brown or other coloring substances are preferable in many cases, especially for painting wood. Very neat, dark-brown to black shades are obtained by a suitable mixture of fuchsin resinate with green or blue, chrysoidin or auramin resinates. Such mixtures are very suitable for printing and lithographing inks. With dilute solutions of resin pigments in benzol, textile fabrics can be dyed in a bath, this method being used for silk, silk ribbons, satins and artificial flowers whose colors are to be fast. They can further be used for dyeing and printing caoutchouc and caoutchouc wares, celluloid, oil-cloth, linoleum, etc., also for coloring white lead, zinc white, sulphide of zinc, heavy spar, chalk. In an undried, paste-like amorphous condition, they are suitable for the fabrication of colored pencils, and compounded with gum tragacanth, starch or albumen for printing wall-papers, whereby through the action of the vapor of their solvent they pass into the dissolved, transparent state in which they adhere like varnish upon every surface.

French Polish.—The preparation of French polish is very similar to that of other spirit and naphthalic varnishes. Sometimes it is colored in order to change to a greater or less extent the hue of the wood to which it is applied. A reddish tinge is given with dragon's blood, alkanet root, or red sanders wood; and a yellow tinge by turmeric root and gamboge. When it is simply required to darken the wood, brown shellac is employed to make the polish; and when the object is to keep the wood light colored, a little oxalic acid (2 to 4 drachms to the pint) is commonly added. These substances are either steeped in or agitated with the polish, or with the solvent before pouring on the "gums," until they dissolve, or a sufficient effect is produced. French polish is not required to be clear and limpid, and is, therefore, never artificially clarified. The process of polishing with it is thus performed: The surface to be operated on being finished off as smoothly as possible with sand-paper, and placed opposite the light, the polish being on hand in a narrow-necked bottle, the polisher moistens the flat face of the rubber of the polish by laying the rubber on the mouth of the bottle and shaking up the varnish. The operator next places the rubber, which has imbibed a portion of the varnish, in a soft linen cloth doubled, the rest of the cloth being gathered back from the handle. The face of the linen is now moistened with a little raw linseed oil, applied with the finger to the middle of it, and the operation of polishing is immediately commenced. The rubber is passed quickly and lightly over in circular sweeps, until the varnish is very nearly dry, when the rubber is used without the oil. Three coats are thus successively laid on. A little oil is then applied to the rubber, and two more coats are given. As soon as the coatings of varnish have acquired some thickness, the varnish is dampened with alcohol or wood naphtha, to secure a quick, light, uniform touch. The work is finally carefully gone over with a linen cloth moistened

with a little oil, and rectified spirits or naphtha without varnish, and rubbed as before until dry.

Several varnishes are used under the name of French polish. That most generally employed is a simple solution of the shellac and alcohol. Sometimes a little mastic, sandarac or elemi, or copal varnish is added to render the polish tougher. The following preparations are now in general use:

1. Pale shellac, 5½ ozs.; finest wood naphtha, 1 pint. Dissolve.
2. Pale shellac, 3 lbs.; wood naphtha, 1 gallon, or methylated spirit in place of the latter.
3. Pale shellac, 5 ozs.; gum sandarac, 1 oz.; spirit, 1 pint.
4. Pale shellac, 5½ ozs.; gum elemi, a piece three-quarter inch square; spirit, 1 pint.
5. Pale shellac, 1¼ lbs.; mastic, ¼ lb.; spirit, 2 quarts.
6. Pale shellac, 2¼ lbs.; mastic and sandarac, of each 3 oz.; spirit, 1 gallon. Dissolve and add 1 pint copal varnish, and mix by agitating the vessel.
7. Shellac, 12 oz.; wood naphtha, 1 quart. Dissolve in ½ pint linseed oil.
8. Shellac, ½ lb.; gum sandarac, ¼ lb.; spirit, 1 quart. Dissolve and add ¼ pint of copal varnish; mix well, and then add ½ pint linseed oil. The last two require no oil on the rubber.

Furniture Polish.—Mix 100 parts by weight of linseed oil, 750 of ether, 1000 of rectified oil of turpentine, and 1000 of benzine, and perfume with a volatile oil; the latter may, however, be omitted. Apply the mixture with a woolen rag. For special purposes the preparation may be colored with turmeric, annotto, alkanet, etc.

Varnishes for Toys.—1. Melt in an iron pot with constant stirring, 32.5 lbs. of comminuted, yellow, transparent American resin. When thoroughly melted remove the fire from under the pot and intimately mix with the melted resin 48.75 lbs. of oil of turpentine. The varnish thus prepared is filtered through a woolen cloth and kept for use in large glass balloons thoroughly stoppered.

II. In a large vat dissolve without the application of heat but with constant stirring 27.5 lbs. of comminuted, yellow, transparent American resin, and 22 ozs. of Venetian turpentine in 41.25 lbs. of 85 or 90 per cent. alcohol. Filter the varnish through a woolen cloth, and keep in well-stoppered bottles.

Transparent Varnish for Metals.—For a green transparent varnish for metals, grind a small quantity of Chinese blue with double the quantity of finely powdered chromate of potash (it requires the most elaborate grinding); add a sufficient quantity of copal varnish thinned with turpentine. The tone may be altered by adding more or less of one or the other ingredients.

Copal Varnish for Labels.—A copal varnish better than dammar for labels is made by first dissolving 5 parts of camphor in 60 of ether, then add 20 parts of finely powdered gum copal, shake well once in a while for a couple of days, when the copal will be partly dissolved, partly only swollen. Now add 20 parts of absolute alcohol and 2 of oil of turpentine. Shake well at times for a couple of days, and let stand. Draw off the clear liquid for use.

Varnishing Marble Paper.—Before commencing to varnish the paper give the same one or two coats of weak size made from glue, being careful to touch every part of it or it will show gray. When dry it is ready for varnish. The glue must be clear or it will tint the varnish. All paper will not varnish.

How to Keep Varnish.—A varnish made with alcohol will get dull and spongy by the evaporation of the alcohol, which leaves water in the varnish, as all commercial alcohol contains water. It is, therefore, advisable to take a thin sheet of gelatine, cut it into strips and put it into the varnish; it will absorb in the thin sheet most of the water, and the varnish can be used clear and bright till the last drop. The gelatine will get quite soft. It can then be taken out and used again.

Marbling.—An *Italian pink marble* surface is produced as follows: Over a white ground apply a coat, the pigment being mixed with equal quantities of turpentine and oil. Proceed to lay on tints of ultramarine and white lead and vermilion, each of these pigments being mixed with equal quantities of oil and turpentine, and with these dab patches, using a sable pencil, and subsequently softening the work with a badger. On the palette place some Indian red, and with a small pigeon feather dipped in the turpentine and some of the Indian red, work the pattern and well-soften. When this is dry mix some white lead rather thinly with turpentine and flat the whole of the work; then with a feather dipped in turpentine scumble over the work, and subsequently put in whites with white lead and turpentine. When the surface is hard, varnish.

For *Florentine marble* the ground is white. Indian red and black, mixed together, form a very light reddish neutral tint, which is next to be applied over the surface. The veins are umber and burnt sienna; they are laid on very irregularly, while the ground-color is wet; sometimes they are very close together, and then seem to break suddenly into the forms of rocks and ruins—an effect which must be studied from natural specimens, and be imitated by hand.

To imitate *verde antique marble* the ground must be either black or dark-green. The marbling colors are dark-brown and green. Scumble over the work with these; then with Brunswick green and white lead scumble over again and soften with a badger; next with a fitch paint masses of white of various shapes, as squares, irregular triangles, etc.; also insert masses of black. The latter have a certain darkening effect on the browns and greens. For blue and gold marbling the ground must be of a light-blue, and when this is quite dry dab on in separate patches, light-blue, white and Prussian blue, leaving portions of the ground visible. Soften these patches together, and then vein in every direction with white and fill up some of the irregular spaces with yellow or gold paint and finally add white veins.

How to Handle and Lay Gold Leaf.—Procure a surface board 2½ feet in length and 8 inches wide. Lay your book of leaf on this board, and with a knife or pair of shears cut the back of the leaves off where they are bound together. Take a small piece of unbleached muslin, wet it with clean turpentine, and with this rub over the top layer of paper. Lift the paper and place on your board so the edge of the paper will extend half an inch or so over the edge of the board so you

can pick it up with ease. Care should be taken not to get the cloth too wet or the turpentine will go through the first layer of paper and leaf to the second and stick the two together. Proceed in this way until about half of the book is lifted, if you need that much. It is best not to lift too much at a time until you get it cut the size wanted, as it will handle and cut much nicer if done while the paper is damp.

The above process is intended for large strips only. For $\frac{1}{4}$ inch strips and under, in place of wetting with turpentine, lift the first layer of paper and give it a few rubs on your trousers' leg to get the chalk off, and then a few rubs on your hair. Then place back on the leaf, and press evenly and hard with the edge of your hands. Take care to keep the paper from moving on the leaf, as it will tear it, if moved the least bit.

One leaf can be cut in pieces small enough to lay 8 or 10 feet of stripe, and, with a little practice, it can be done very speedily too. In cutting, hold the paper so the pieces will fall on the board with their ends extending over the edge half an inch, so you can pick them up with the thumb and forefinger. Never attempt to cut the leaf with new or newly ground shears, but get the ones with which your wife allows the children to make paper dolls, and you will find those just right.

In using turpentine, do not lift more than will do the job in hand, as it will dry up and come off and be wasted, or stick to the paper so you cannot get it off. In using the outside leaf or cover put it on while quite wet or the leaf will not come off. The finish on the paper will stick the leaf and paper together if allowed to dry. If painters will try this method they will find they can lay twice the amount of leaf in the same time and with very little waste.

Japan Dryer.—Take of linseed oil 5 gallons, red lead and litharge each $3\frac{1}{2}$ lbs., raw umber $1\frac{3}{4}$ lbs., and sugar of lead $\frac{3}{4}$ lb. Pulverize and mix together the ingredients named, and add them to the oil, and boil or simmer them over a steady fire for two or three hours. Remove the kettle, and when the oil has become cooled down to a certain degree add 5 gallons of turpentine. Having stirred the mixture thoroughly, allow it to remain quiet for ten or twelve hours, then pour it off carefully and can it. It will then be ready for use.

Gold Beetle-colored Bronze.—Mix equal parts of chromate of potash and table salt. After the powder is finely mixed, let it pass through a sieve, then put this powder into a crucible and cover it with a layer of salt. Cover the crucible and allow the contents to boil half an hour. After cooling wash out the contents carefully with water, and the mass on being rubbed will show a beautiful bronze.

Approved Method of Painting Tin Roofs.—The composition of the paint is as follows: Venetian red 10 lbs., red lead 1 lb., and 4.5 quarts of pure linseed oil. A partial substitution of benzine or train-oil for linseed oil injures the durability and quality of the paint. The roof lasts longer and the tin is less inclined to rust if the lower side is also painted before placing the tin on the roof. It is also recommended to lay one or two layers of felt-paper under the tin. This forms, so to say, a cushion for the tin, and also deadens the noise of

rain falling upon the roof. The coat of paint should be renewed after the first year, and later on every four years.

New Method of Rendering Brick Walls Impermeable to Water.—This new method of rendering brick walls impermeable to water is known as the Sylvester process. It consists in the successive application of two coatings, one of soap and water, and one of alum and water. For the soap solution 11 ozs. of soap are dissolved in 1 quart of water, and for the alum solution 7 ozs. of alum in 4 quarts of water. The walls must be dry and clean, and the temperature of the air not exceed 50° F. The soap solution is first applied boiling-hot with a flat brush. After twenty-four hours, when this coating is hard and dry, the alum solution is applied at a temperature of from 61° to 70° F. After twenty-four hours the entire process is repeated until the wall is impermeable. The number of coatings required depends on the water pressure to which the walls are exposed.

To Renovate Old Brick Walls.—Old brick walls may be enlivened and renewed by this process: Remove any mouldy green that may have accumulated by pouring over the bricks boiling water (not greasy), in which any vegetables have been cooked. Repeat for a few days and the green will disappear. To prepare a red wash, melt 1 oz. of glue in a gallon of water, and while hot, add a piece of alum as large as a hen's egg, ½ lb. of Venetian red, and 1 lb. of Spanish brown. If the color, upon trying this paint, is found to be too light, add more brown and red; if too dark, put in more water.

Whitewash for Indoor Work.—An excellent whitewash for indoor work is made of 2 lbs. Paris whiting, 1 oz. white glue; dissolve the glue in warm water. Mix the whiting with warm water, stir in the glue and thin with warm water.

To Prepare Zinc for Painting.—Apply sulphuric acid and water for a quarter of an hour; then wash off clean with water, and dry.

Waterproof Whitewash.—Mix together the powder from 3 parts silicious rock (quartz), 3 parts broken marble and sandstone, also 2 parts of burned porcelain clay, with 2 parts freshly slaked lime, still warm. In this way a wash is made which forms a silicate if often wetted, and becomes, after a time, almost like stone. The four constituents mixed together give the ground color, to which any pigment that can be used with lime is added. It is applied quite thickly to the wall or other surface, let dry one day, and the next frequently covered with water, which makes it water-proof. This wash can be cleansed with water without losing any of its color; on the contrary, each time it gets harder, so that it can even be brushed, while its porosity makes it look soft. The wash or calcimine can be used for ordinary purposes as well as for the finest painting. A so-called fresco surface can be prepared with it in a dry way.

METAL AND STONE.

Polishing Agents for Metals.—I. *Polishing (Putz) Soaps.* 1. Stir

into 25 lbs. of liquid cocoanut oil soap 2 lbs. of tripoli and 1 lb. each of alum, tartaric acid and white lead.

2. Stir into 25 lbs. of liquid cocoanut oil soap 5 lbs. of colcothar (jeweller's rouge) and 1 lb. of ammonium carbonate.

3. Mix 25 lbs. of liquid cocoanut oil soap with 4 to 5 lbs. of glowed oxalate of iron.

4. Stir together 24 lbs. of cocoanut oil with 12 lbs. of lye of 38° to 40°, and when the mass appears bright add 3 lbs. of colcothar, mixed with 3 lbs. of water, and, finally, 1 oz. 2 drachms of spirit of sal-ammoniac.

5. 332 parts by weight of white bole or chalk, the same quantity of tartaric acid, and 265 parts of infusorial earth, are first finely powdered, and the bole, chalk, and infusorial earth freed from adhering pebbles by sifting. The sifted mass is then brought into a vessel, and after pouring water over it and thoroughly stirring, the bole, or chalk, etc., which is finely divided in the water, is poured off, and the operation repeated once or twice. The bole is then allowed to deposit on the bottom of the vessel, and after carefully pouring off the supernatant liquid, is brought upon a filter and completely dried in a stove. To the bole, etc., thus prepared, are added 200 parts by weight of glycerine, the same quantity of water, and 25 parts of alcohol.

6. Reduce 5½ lbs. of cocoanut soap to fine shavings, add some water and melt. To the melted soap add then, with vigorous stirring, 6 ozs. 5 drachms of chalk, 3 oz. 2 drachms each of alum, tartaric acid and white lead.

II. *Polishing (Putz) Pomades.* 1. Melt 5 lbs. of lard or yellow vaseline and stir into the melted mass 1 lb. of fine colcothar.

2. Melt 2 lbs. of palm oil and 2 lbs. of vaseline and stir into the melted mass 1 lb. of ferric oxide, 14 ozs. of tripoli, and 12 drachms of oxalic acid.

3. Heat 4 lbs. of fat American mineral oil and 1 lb. of lard and stir into the melted mass 5 lbs. of fine colcothar.

Putz pomade is generally perfumed with some essence of mirbane (nitrobenzole), and packed in small tin boxes.

III. *Polishing Powders.* 1. Mix intimately 4 lbs. carbonate of magnesia, 4 lbs. of calcium carbonate, and 7 lbs. of ferric oxide.

2. Mix 4 lbs. of carbonate of magnesia with 5 ozs. 4 drachms of elutriated colcothar.

IV. *Polishing Rags.* Polishing rags for metals are prepared from a woolen stuff saturated with soap and tripoli, and colored with coralline, as follows: 1 oz. 6 drachms of Castile soap are dissolved in 7 ozs. of water. Add to the solution 11 drachms of tripoli, and color red with coralline. The above quantity suffices for the saturation of 10 pieces of stuff, each about 27 inches long and 3¾ inches wide.

Polishing Water.—An excellent, and at the same time harmless, polishing water is obtained by shaking together 8 ozs. 13 drachms of whiting, 1 lb. of alcohol, and 11 drachms of spirit of sal-ammoniac.

Polishing Agents for Noble Metals.—I. *Polishing Powder for Gold Workers.* Mix together carbonate of lead 4.3 parts, carbonate of lime (chalk) 17.4, carbonate of magnesia 1.7, alumina 4.3, silica 2.6, jeweller's rouge 1.7.

II. *Polishing Powders for Silver.* 1. Mix intimately finely pulverized cream-of-tartar 4 parts, Spanish white 8 parts, pulverized

alum 2. Knead the mixture to a stiff paste, with strong wine vinegar, and expose it to the air. When dry pulverize the mass, make it again into a paste with spirits of wine, and again repeat the same process after drying. Finally pulverize the mass thus obtained.

2. Mix intimately: Burnt hartshorn, finely pulverized, 1 part, chalk 5 parts, colcothar 1 part.

3. Mix intimately by sifting 10 parts of the finest whiting, and 1 part of soda and $\frac{1}{4}$ part of citric acid, both reduced to a fine powder. For use the powder is moistened with water so that the soda and citric acid dissolve, and act chemically upon the silver.

4. Mix intimately by repeated sifting, so that the whole forms a powder of a uniformly reddish color in which no red or white particles can be observed, whiting 250 parts, pipe-clay 117, white lead 62, magnesia 23, jeweller's rouge 23.

III. *English Silver Soap.* This soap, which may be used for giving silver articles a beautiful lustre by brushing, is prepared as follows: Dissolve 2 parts of Castile (pure olive oil) soap in 2 parts of soft water over a fire, and stir into the melted mass 6 parts of elutriated chalk. The soap is brought into moulds and allowed to cool.

IV. *English Rose-color Silver Soap.* This soap is prepared in the same manner as the preceding, but instead of 6 parts of elutriated chalk, the following ingredients are stirred into the melted mass: Fine white tripoli 2 parts, pulverized chalk 3 parts, and jeweller's rouge 1 part. Before pouring the soap into moulds it is perfumed with a few drops of oil of lavender, whereby it acquires an excellent odor which contributes towards its ready sale.

V. *Polishing Balls for Silver.* This polishing agent consists of polishing powder brought into the form of a ball by means of an agglutinant. It is prepared by thoroughly mixing 2 parts of yellow tripoli and 5 parts of elutriated chalk, and making the mixture into a paste with a solution of 1 part of gum arabic in 12 parts of water. The paste is then formed by the hand into balls the size of a pigeon's egg. The balls are dried in a moderately warm room and finally wrapped in tinfoil.

VI. *Silver Polishing (Putz) Pomade.* Perfume 3 parts of American vaseline with a few drops of essence of mirbane (nitrobenzole), and stir into it so that an intimate mixture of the consistency of butter is formed, 5 parts of elutriated chalk, 1 part of burnt hartshorn, and 1 part of pulverized *Ossa sepia* (cuttle-bone). The pomade is packed in small tin boxes.

Polishing Paste for Brass.—Dissolve 15 parts of oxalic acid in 120 of boiling water, and add 500 parts of pulverized pumice stone, 7 of oil of turpentine, 60 of soft soap, and 65 of any kind of fat oil.

Rouge for Polishing Metals.—As the rouge found in the market does not meet the requirements of the workman, at least for every metal, we give a very simple method which allows the workman to prepare for himself just the quality and quantity necessary for his particular work. Heat sulphate of iron of as pure a quality as can be obtained in an iron vessel over a slow fire, stirring it continually with an iron spatula till it is dry, and takes the form of a pale greenish-yellow powder. This powder, after being crushed in a mortar and sifted, is to be calcined in a new crucible, and exposed to the fire of a smelting stove as long as vapors arise from it. As soon as no more of these can

be observed, the contents of the crucible may be left to cool, and when cool will appear like the rouge used for polishing. Its color may vary from pale red to brown red, or even to blue and violet, but these variations arise only from the different degrees of heat employed; and it may be observed that the higher the temperature has been during the process the darker the color, and the harder the powder—a fact which also explains why the pale-red powder is used only for gold and silver, while the violet is employed for steel. No matter what the color is, it is very important that the rouge be well bruised and washed in water before it is used. For this purpose three clean glasses are taken and one of them is filled with pure water, in which a part of the rouge is mixed by stirring it for some time with a small piece of wood. After allowing about half a minute for the rouge to settle to the bottom of the glass the remainder of the (red) liquid is decanted into the second glass, but every particle of the deposit must be left in the first one. The same process has to be observed also for the second and third glasses, but with this difference: the powder in the second glass is allowed to settle about two minutes, while in the third one it is left for several hours, that is, until the water assumes its natural clearness. The sediment of the first glass is almost valueless, that of the second of medium quality, but that of the third glass is of a very good quality, and fit to be used with great advantage after it has been slowly dried. In some cases the rouge thus obtained may be mixed with grease, and generally it will be found of great advantage to moisten it with spirits of wine, and burn it in a clean iron vessel.

Cleaning Metal and Stonework.—The surfaces to be cleansed are submitted to the action of a jet of mixed (dilute) hydrochloric and sulphuric acids and left for 2 or 3 hours, when they are brushed and finally washed with a water jet. In the case of lime-stone the hydrochloric acid unites with the calcium, forming chloride of lime, which is then decomposed by the sulphuric acid, forming a calcium sulphate, this being precipitated on the face of the stone and containing all the impurities, which are then removed by the action of the brush and water jet. In many cases this treatment will not succeed unless the stone is previously prepared, as the masonry becomes coated with a deposit of impurities contained in the atmosphere which prevents the acids reaching the stones. In this case, before applying the acids, the stone is covered with a paste consisting of a mixture of carbonate of soda and calcium hydrate, which is called "tolugene." It is spread over the masonry to a thickness of from ½ to 1 millimetre and left there for three-quarters of an hour to an hour, when the excess is washed down and brushed off and the acids applied as described. In cleaning ironwork the "tolugene" alone is used. It is spread over the work either with a trowel or brush, and in the course of an hour or so will have united with all the oil of the paint, leaving the red-lead on the work in the form of a powder, which can easily be washed off with a jet of water. In cleansing brick the work is first painted with a solution of ammonium fluoride, and this immediately afterwards is treated with a jet of concentrated sulphuric acid, which liberates hydrofluoric acid, and this attacks the silicates, depriving them of their silica. The whole surface is afterwards thoroughly washed with water.

To Clean Marble Ornaments.—In cleaning marble ornaments, etc., great care must be exercised to use nothing corrosive, like acids,

chlorides or metallic salts, such as are usually recommended for removing stains of ink and dyes from wool and textile fabrics. When marble has been stained by ink or vegetable coloring matter the only way to remove it is to apply warm water abundantly and for a long time. If the marble is very compact, and the stain consequently quite superficial, the article may be scraped and repolished, but, of course, this is applicable only to objects which have plain surfaces or those with simple curves. Elaborately carved or sculptured objects could not be so treated. Greasy stains may be removed by covering them with a paste of chalk and potash or soda. The alkali will convert the grease into soap, which will be gradually absorbed by the chalk and thus removed. In such cases, however, the stains, especially if old, may require a long time and several repetitions of the process. Alkalies (potash, soda and ammonia) may be applied to marble without injuring it.

Polishing Granite.—The form is given to the stone by the hands of skilled workmen in much the same way as is done with other stones of a softer nature. Of course the time required is considerably greater in the case of granite as compared with other stones. If the surface is not to be polished, but only fine-axed, as it is called, that is done by the use of a hammer composed of a number of slips of steel about one-sixteenth inch thick, which are tightly bound together, the edges being placed on the same plane. With this tool the workman smooths the surface of the stone by a series of taps or blows given at a right angle to the surface operated upon. By this means the marks of the single axe by which the blows are given obliquely on the surface of the stone are obliterated and a smooth face produced. Polishing is performed by rubbing in the first place by an iron tool and with sand and water. Emery is next applied; then putty with flannel. All plain surface and moulding can be done by machinery, but all carvings or surfaces broken into small portions of various elevations are done by hand. The operation of sawing a block of granite into slabs for panels, tables or chimney pieces is a very slow process, the rate of progress being about half an inch per day of ten hours. The machines employed are few and simple. They are technically called lathes, wagons and pendulums or rubbers. The lathes are employed for the polishing of columns, the wagons for flat surfaces and the pendulums for mouldings and such flat work as is not suitable for the wagons. In the lathes the column is placed and supported at each end by points upon which it revolves. On the upper surface of the column there are laid pieces of iron, segments of the circumference of the column. The weight of these pieces of iron lying upon the column, and the constant supply by the lathe-attendant of sand and water, emery or putty, according to the state of finish to which the column has been brought, constitute the whole operation. While sand is used during the rougher state of the process, these irons are bare, but when using emery and putty the surface of the iron next to the stone is covered with thick flannel. The wagon is a carriage running upon rails, in which the pieces of stone to be polished are fixed, having uppermost the surface to be operated on. Above this surface there are shafts placed perpendicularly, on the lower end of which are fixed rings of iron. These rings rest upon the stone, and when the shaft revolves they rub the surface of the stone. At the same time the wagon travels backwards and forwards upon the rails, so as to expose the whole surface of the

stone to the action of the rings. The pendulum is a frame hung upon hinges from the roof of the workshop. To this frame are attached iron rods moving in a horizontal direction. In the line upon which these rods move, and under them, the stone is firmly placed upon the floor. Pieces of iron are then loosely attached to the rods and allowed to rest upon the surface of the stone. When the whole is set in motion these irons are dragged backward and forward over the surface of the stone, and so it is polished. When polishing plain surfaces, such as the needle of an obelisk, the pieces of iron are of course flat, but when a moulding is to be polished an exact pattern of its form is made and the irons cast from that pattern.

To Mend a Broken Dial.—Plaster of paris, mixed with a medium strong solution of gum arabic in water and applied instantly after mixing, makes a fine white filling and dries quite hard after an hour or two. Shave off with a sharp knife and polish with a piece of white flannel. Shellac dissolved in strong spirits of ammonia makes a good cement for fastening on chips of a dial which have been broken off.

How to Remove Old Watch Jewels when Set in the Plate.—Jewels can be removed from full plates by putting the plate into a glass tumbler and pouring on nitric acid. The jewels will become loose and after a little time drop out. Wash the jewels well with a little soda or ammonia.

How to Fasten a Ribbon into Gold Mountings.—Ribbons are fastened into metal tips with shellac. Heat the shellac and work it into a stick. Then heat the sticks and smear some on the ends of the ribbon. The tips should also be heated when the end of the ribbon covered with shellac is pushed in.

To Frost Watch-plates.—Watch-plates are frosted by means of fine brass wire scratch brushes, fixed in a lathe and made to revolve at great speed, the end of the wire brushes striking the plate, producing a beautiful frosty appearance.

To Cleanse Silverware.—Sodium hyposulphite furnishes the most simple and cleanly polishing agent for silverware. It acts quickly, is cheap and can be especially recommended for the purpose. A rag or brush moistened with saturated solution of the salt cleans in a few seconds, without the use of polishing powder, strongly oxidized surfaces of silver.

To Renovate Nickel Watch Movements.—In consequence of changes in temperature or other influences, it sometimes happens that nickel movements turn yellow or become stained. They can be readily renovated as follows: To 50 parts of rectified spirit add 1 part of sulphuric acid. Put the parts to be renovated in this fluid for 10 to 15 seconds; to allow them to remain longer is injurious. Then dip them in clean water, and after thoroughly rinsing off, place them for a short time in rectified spirit. Finally, dry in sawdust or with soft linen. Nickel movements thus treated become almost like new, and the polish is not injured, as would be the case if the parts were treated with the leather-file or brush.

To Remove Rust from Nickel-Plated Articles.—Oil the articles thoroughly, let them stand a few days, and then rub vigorously with a cloth moistened with ammonia. If this method should not produce the desired success, moisten the stains alone with dilute hydrochloric acid, and rub off immediately. The articles are then washed, and after drying polished with tripoli or some other polishing powder.

To Clean Old Brass.—To clean old brass, especially small figures, mountings, etc., so as to give them the appearance of new, the following process is highly recommended: Into an earthen or glass dish pour a sufficient quantity of a mixture of 1 part of nitric acid and ½ part of sulphuric acid to allow of the entire article being dipped into the fluid. After remaining in the fluid for a short time the article is taken out, quickly washed in cold water, thoroughly dried in sawdust, and finally polished with finely powdered Vienna lime.

To Restore the Lustre of Dead Silver Work, Gilt Clock Cases, etc.—Dissolve 1 oz. of cyanide of potassium in 1 quart of pure water, empty the solution into a bottle and label it "poison." When to be used place the article in an earthen vessel, cover it over with the solution, and in five minutes the lustreless appearance will be removed. Preserve the fluid for future use.

Recutting Files by Electricity.—Files can be recut by cleaning them, and placing them in acidulated water between two plates of carbon, and closing the circuit so as to form a real voltaic cell. The hydrogen liberated clings to the points of the teeth of the file, protecting them from further action, but the cutting action proceeds freely over the remainder of the file. This process speedily brings back the teeth of an old file to the original shape and dimensions, and does not merely sharpen them but practically recuts the file, without necessitating either softening or retempering the metal.

To Renovate Old Files.—Cleanse the file from all foreign matter, and then dip it into a solution of 1 part nitric acid, 3 parts sulphuric acid, and 7 parts water. The time of immersion will be according to the extent the file has been worn and the fineness of the teeth, varying from 5 seconds to 5 minutes. On taking it out of the mixture wash in water, then dip in milk of lime; wash off the lime, dry by a gentle heat, rub over equal parts of olive oil and turpentine, and finally brush over with powdered coke.

Detection of Iron or Steel.—Aquafortis, applied to the surface of steel, produces a black spot; on iron the metal remains clean. The slightest vein of iron or steel can readily be detected by this method.

Simple Method to Ascertain the Quality of Iron or Steel.—Good iron is readily heated, is soft under the hammer, and throws out few sparks.

Coarse grain, with bright crystallized fracture or discolored spots, indicates cold-short, brittle iron, which works easily when heated, and welds well. Cracks on the edge of a bar are indications of hot-short iron. A medium, even grain with fibres, denotes good iron.

A soft, tough iron, if broken gradually, gives long silky fibres of leaden-gray hue, which twist together and cohere before breaking.

Badly refined iron gives a short, blackish fibre on fracture. A very fine grain denotes hard, steely iron, likely to be cold-short and hard.

To Detect Alloys in Gilding.—A solution of chloride of copper will show the difference between gilding for which gold has been used and gilding with alloys of inferior metals. If the gilding be imitation gold, a touch of the solution will give a black mark, copper separating out through the zinc in the yellow metal; with pure metal no discoloration will occur. The test can also be effected with a solution of chloride of gold or nitrate of silver, the first of which will give a brown spot, the second a gray or black spot; neither has any effect on gold. Common gold goods of 14-karat gold will not change their color with nitrate of silver. Leaf-gold is tested by being shaken up in a closed bottle with sulphur chloride. Beaten gold will show no alteration, while "metal" leaves will grow gradually dark.

Bending of Cast-Iron.—A flat-shaped casting weighing 300 lbs. was required to be bent in two places in the direction of its length. For this purpose the casting was heated on the places to be bent, by two alcohol lamp-flames. After the heating had proceeded to about the temperature at which hardened steel acquires a straw color, pressure was exerted by means of a loaded lever upon the upper part of the casting, opposite to the flames, and the latter were by degrees directed to other portions of the intended bend. The iron yielded to the combined effects of heat and pressure thus gradually brought to bear upon it, so that the casting actually assumed the bend intended to be produced, and which could not be otherwise obtained by planing or other treatment. The deposits upon the casting produced by the lamps were removed with emery cloth. From this experiment it is concluded that it is possible to bend cast-iron to a considerable extent, provided it is subjected to careful treatment at a very moderate heat and the simultaneous action of a suitable uniform pressure.

Softening Cast-Iron.—Cast-iron, in pieces of moderate size, may be softened by heating to a red heat and plunging into warm water, then raising once more to a red heat and cooling very slowly.

To make a Flange Joint that will not leak or burn out on steam pipes, mix 2 parts of white lead and 1 part of red lead to a stiff putty; spread on the flange evenly.

New Way of Annealing Steel.—Heat the piece as slowly as possible, and when at a low red heat put it between two pieces of dry board, and screw them up tight in a vise. The steel burns its way into the boards and, on coming together around it, they form a practically air-tight charcoal bed. When it cools off the steel is apt to be found thoroughly annealed.

Two Ways of Annealing Steel.—It can be heated to a dull, red heat, covered with dry, warm sand, and left to cool slowly, or heat and cover up in the forge fire, and leave it there until the fire is out and all is cold. The other method is to heat the steel red hot; heat gradually, let it "soak," as the smiths say, until it is evenly heated, then remove it from the fire and take it to some dark place. Let the steel cool until you lose sight of the dull red in the dark, then cool off in cold water. A good "dark place" may be made by throwing your

coat over a barrel, leaving just room enough to look in at the iron. This method is called "water anneal," and is based upon the theory that steel softens when cooled at a certain temperature.

Electricity for Tempering Steel.—Electricity has been successfully applied to tempering watch springs and other forms of spring steel, whether in the shape of ribbon or wire. The steel is wound on a spool, whence it passes down through a bath of oil. An electric current is sent through a wire of such strength as to keep it at the proper redness to answer the desired requirements of temper. As the heating is not done in contact with the air, but is entirely beneath the surface of the oil, there is no trouble from blistering, as in the ordinary methods. The final temper is drawn in the same manner, and the wire or ribbon is finished by means of rolls. The process is also applied to a number of springs besides those for watches, including piano wires. In all cases the process can be controlled to a nicety, both as to the exact temper and its uniformity through the wire.

Heating Steel.—There are three distinct stages or times for heating: First, for forging; second, for hardening; third, for tempering.

The first requisite for a good heat for forging is a clean fire and plenty of fuel, so that jets of hot air will not strike the corners of the piece; next, the fire should be regular, and give a good uniform heat to the whole part to be forged. It should be keen enough to heat the piece as rapidly as may be, and allow it to be thoroughly heated through without being so fierce as to overheat the corners.

Steel should not be left in the fire any longer than is necessary to heat it clear through, as "soaking" in fire is very injurious; and, on the other hand, it is necessary that it should be heated through to prevent surface cracks, which are caused by the reduced cohesion of the overheated parts which overlie the colder centre of an irregularly heated piece.

By observing these precautions a piece of steel may always be heated safely up to even a bright-yellow heat when there is much forging to be done on it, and at this heat it will weld well.

The best and most economical welding flux is clean, crude borax, which should be first thoroughly melted and then ground to a fine powder. Borax prepared in this way will not froth on the steel, and one-half of the usual quantity will do the work as well as the whole quantity unmelted.

After the steel is properly heated it should be forged to shape as quickly as possible, and just as the red-heat is leaving the parts intended for cutting edges, these parts should be refined by rapid light blows, continued until the red disappears.

For the second stage of heating, for hardening, great care should be used; first, to protect the cutting edges and working parts from heating more rapidly than the body of the piece; next, that the whole part to be hardened be heated uniformly through without any part becoming visibly hotter than the other. A uniform heat, as low as will give the required hardness, is best for hardening.

Bear in mind that for every variation of heat which is great enough to be seen, there will result a variation of grain, which may be observed by breaking the piece; and for every such variation of temperature there is a very good chance for a crack to be found. Many a costly tool is ruined by inattention to this point.

The effect of too high heat is to open the grain; to make the steel coarse.

The effect of an irregular heat is to cause irregular grain, irregular strains and cracks.

As soon as the piece is properly heated for hardening it should be promptly and thoroughly quenched in plenty of the cooling medium, water, brine or oil, as the case may be.

An abundance of the cooling bath, to do the work quickly and uniformly all over, is necessary to good and safe work.

To harden a large piece safely a running stream should be used.

Much uneven hardening is caused by the use of too small baths.

For the third stage of heating, to temper, the first important requisite is again uniformity. The next is time. The more slowly the piece is brought down to its temper the better and safer is the operation.

When expensive tools, such as taps, rose-cutters, etc., are to be made, it is a wise precaution and one easily taken to try small pieces of the steel at different temperatures, so as to find out how low a heat will give the necessary hardness. The lowest heat is the best for any steel. The test costs nothing, takes very little time and very often saves considerable loss.

Etching Liquid for Steel.—Mix 1 oz. of sulphate of copper, ¼ oz. of alum and ½ teaspoonful of salt reduced to powder with 1 gill of vinegar and 20 drops of nitric acid. This liquid may be used either for eating deeply into the metal or for imparting a beautiful frosted appearance to the surface, according to the time it is allowed to act.

Adam Schaefer's Fluid for Hardening Steel, which serves to improve the quality of many varieties of steel, consists principally of ordinary resins, linseed oil, glycerine and powdered wood charcoal, the ingredients being intimately mixed and the mixture heated. The steel at a bright cherry-red heat is dipped in the fluid, and, after cooling in it, again heated and subjected to one of the usual methods of hardening by water, oil or melted compositions of metal. The effect produced by this process is said especially to show itself in burnt cast steel, which thereby regains its original qualities, while softer varieties of steel acquire the advantages of cast steel. Tools made from Bessemer steel, which cannot be hardened in the usual manner, may, after passing through the above-described process, be used for cutting castings which frequently resist the best tools made of tungsten steel.

To Prevent the Baking of Moulding Sand.—Moulding sand consists chiefly of quartz sand and clay, the latter serving as an agglutinant for the former. On the proportion of these two essential constituents and on the fineness of the sand depends the availability of the latter to moulding. The content of clay, on the one hand, must not be so large that the sand becomes hard by the slight glowing caused by contact with the fluid metal, and, on the other, must be sufficiently large to impart to the sand the required coherence after moistening and pressing together. The baking of moulding sand is *decreased* by an addition of soot and coal powder and *promoted* by an addition of beer yeast, beer, molasses, rye flour, etc. A content of lime is injurious to moulding sand. In many places available moulding sand is found which need only to be comminuted and sifted to be

ready for use. If such natural moulding sand cannot be had, it can be prepared by mixing 93 parts of pure quartz sand with 7 parts of clay free from lime. Moulding sand which has been used and has partially lost its agglutinating power can be restored by mixing with fresh sand. Moulding sand should not be stored in the open air, since the finer particles of clay are washed out by rain.

Cores in Heavy Castings.—When cores run through heavy bodies of iron the hot liquid raises the fusible element of the sand to such a high temperature that the grains fuse together, so that when the casting cleaner tries to get the core out he finds it almost as hard as the iron. A good thing to prevent this fusing of the sand is to mix some sea-coal or blacking in it, and to give the surfaces of the core a good body of black lead or plumbago blacking. This outside coat of blacking will prevent the liquid iron from eating into the surface of the core sand, and the sea-coal or blacking mixed in the sand burns away and passes off in the form of gas, leaving a porous body between the grains of sand, which assists in preventing its fusing. In putting rods in such cores as are subjected to high temperature, it is a good plan to coat them with two or three thick coats of flour paste, and dry them in an oven as the paste is put on; for by doing this the dried paste burns off from the rod and leaves it free to come out of the casting.

Melting Zinc.—Zinc is troublesome to cast, and more troublesome when small thin moulds are to be cast. Lining the mould with whiting and water, which must be allowed to thoroughly dry, will often cause the metal to fill the mould well. Burning of the zinc (oxidizing) may be prevented by covering the metal while in crucible or ladle with a layer of common salt or a little muriatic acid, which amounts to the same, as a coat of zinc oxide is immediately formed on the surface of the melted metal, which effectually prevents further oxidation from the action of oxygen in the atmosphere. It is an improvement to keep a layer of charcoal on top of the zinc or any other soft metal which can be melted in a ladle. The coating of oxide forms a protection against oxidation to only a certain degree, while the layer of charcoal tends to reduce the oxide again to its metallic form. Indeed, it is possible to recover lead, tin, zinc and antimony from the "dross" or oxide which gathers in the ladle. It is only necessary to melt the oxide with charcoal, salt and soda to get it again into useful shape. The dross should be powdered; likewise the salt, charcoal and soda. Mix them together and melt. The soda and salt melt into a pasty mass, and the carbon unites with the oxygen of the dross, leaving the metal free, but burning off the charcoal. The salt and soda act simply as flux in reducing the oxides.

Refining and Reducing Zinc Electrically.—The following processes are proposed by Alexander Watt for refining impure zinc by electrolysis, and also for reducing the metal from its ores by electrical deposition.

In the purifying process the zinc is made the anode in a bath containing an organic acid and is dissolved and deposited upon a cathode. Acetic acid is generally used in the process, the ordinary commercial acid being mixed with water in the proportion of one to two. The impure zinc plates are suspended in the bath and the pure zinc is deposited on thin zinc plates or on copper or iron plates coated with

plumbago. When the operation is finished the cathode plates are washed and melted into ingots. To reduce the ores of zinc, especially the carbonate, the minerals are first reduced to a powder and then submitted to the action of the acid, being added a little at a time. When the zinc is completely dissolved the liquid is allowed to stand, and is then drawn off and mixed with water in equal proportions. In electrolyzing this liquid the anode plates are carbon, platinum or some other substance not acted on by the acid; the cathode plates are zinc, carbon, etc. To keep the saturation constant, and to prevent polarization from an excess of free acid, Mr. Watt has devised a system of circulation by which the used-up liquid is restored to its original density in special reservoirs, and is used over and over again. In the treatment of blende or native sulphate of zinc the ores are first roasted, after which they are pulverized and put in acid, as has been described. The process is said to be more economical than those now in use, but it has not been tested by experiment on a large scale.

Refining Silver by Electrolysis.—Möbius, a German electrician, has devised the following simple and inexpensive process for refining silver by electrolysis. It is said to be the best adapted for the refining of auriferous silver. The principle on which the method is based consists in using in an ordinary electrolytic bath anodes of an argentiferous matte and a thin plate of pure silver as the cathode. The bath consists of a very weak solution of nitric acid, containing about 1 per cent. of the acid. The anodes, which are about ½ inch thick, with a surface of about 13.5 square inches, are placed in muslin bags, which retain the gold, platinum, peroxide of lead and similar foreign materials contained in the matte. The current used is 150 ampères and the potential difference between the plates 1 volt. During the whole period of work brushes are kept moving up and down the silver plates, which sweep off the silver deposited into troughs put for the purpose at the bottom of the bath. These troughs are removed from time to time and the silver taken out and sent to the furnace. If the matte contains copper this is dissolved by the nitric acid, but is not deposited on the cathode.

Tempering Magnets.—A combined process for tempering and magnetizing steel bars for magnets is employed by M. Ducoetet. He uses a water-tight vessel, at the bottom of which are two soft iron pole pieces; the poles of a powerful electro-magnet are placed underneath these. The vessel is partly filled with water, and a layer of oil is above this. The red-hot bar is passed through these. Its passage first through the oil is found to soften the steel without depriving it of its power of being magnetized.

Glycerine for Sharpening Edge-tools.—Carpenters and other tool-users are now using a mixture of glycerine instead of oil for sharpening their edge-tools. Oil, as is well known, thickens and smears the stone. The glycerine may be mixed with spirits in greater or less proportion, according as the tools to be sharpened are fine or coarse. For the average blade 2 parts of glycerine to 1 of spirits will suffice.

To Mend Patterns.—For mending patterns needing temporary repairs, or for making additions where but one or two moulds are to be

made, the following material will be found very useful: Melt together 1 lb. beeswax, 1 lb. resin and 1 lb. paraffine wax. It is well to note that the beeswax intended is the wax made by the bees and not the wax made by the wholesale dealers. When the genuine article is used this mixture will be found very useful for making additions to patterns, small temporary patterns, and for a variety of purposes in the pattern-shop.

For Packing the Neck of a Retort.—W. Balcker uses an asbestos string and a cement consisting of clay, 2 parts; pipe-clay, 2; filings free from rust, 2; pyrolusite, 1; common salt, ½, and borax, ½. The ingredients are thoroughly mixed and triturated with sulphate of iron dissolved in water. This cement resists the action of tar oil, steam and heat.

Solvent for Rust.—It is often very difficult, and sometimes impossible, to remove rust from articles made of iron. Those which are most thickly coated are most easily cleaned by being immersed in a solution, nearly saturated, of chloride of tin. The length of time they remain in this bath is determined by the thickness of the coating of rust, 12 to 24 hours being, however, generally sufficient.

To Remove Rust from Iron.—Dip the iron or steel into a concentrated solution of chloride of tin for about 12 to 24 hours. An excess of acid must be guarded against. Take the objects out of the bath, rinse with water and then with ammonia and dry quickly.

To Loosen Rusted Screws.—One of the simplest and readiest ways of loosening a rusted screw is to apply heat to the head of the screw. A small bar or rod of iron, flat at the end, if reddened in the fire and applied for two or three minutes to the head of the rusty screw, will, as soon as it heats the screw, render its withdrawal as easy by the screw-driver as if the screw had been only recently inserted. As there is a kitchen poker in every house, that instrument, if heated at its extremity and applied for a few minutes to the head of the screw or screws, will do the work of loosening; an ordinary screw-driver will do the rest without causing the least damage, trouble or vexation of spirit.

In all work above the common kind where it is necessary to use screws, and particularly in hinge work and mountings, or appliances affixed to joinery or furniture work, it is advisable to oil the screws or dip their points in grease before driving them. This will render them more easy to draw, and it will undoubtedly retard for a longer time the action of rusting.

Rolled Bars Direct from Molten Metal.—This new process of rolling bars or rails direct from the molten metal is the invention of Edwin Norton and John G. Hodgson, of Maywood, Ill. Fig. 67 gives an illustration of the process, together with the principal points in the description as filed in the patent office:—

The process consists in pouring a continuous stream of molten metal from a suitable vessel and simultaneously compressing, setting and shaping the metal by its contact with chilling and compressing surfaces or rolls, which confine or surround the stream on all sides as it passes these continuously moving chilling surfaces or rolls. The chilling surfaces or rolls which shape, compress and set the metal, and thus

convert the molten stream of metal into a metal bar or rail, travel or move at the same surface speed as the velocity of the flowing stream of molten metal, so that the molten metal will not dam up or collect between the rolls, and so that the molten metal or bar product will come in contact with the rolls or chilling surfaces only at a single point, so to speak, at a time.

The metal bars or rails, it will thus be seen, are produced direct from the molten metal, and without first casting the metal into an ingot and heating and rolling and rerolling it; and as the molten metal is poured in a continuous, solid stream into what may be termed a continuously revolving or travelling metal chilling or compressing mould, which comes in contact with only one point, or a very limited length of the metal stream or bar at a time, and is continuously travelling in the same direction with the stream or bar, point after point in the whole length of the metal stream or bar coming successively in contact with this travelling or revolving compressing or chilling mould; the metal bars or rails are, of course, produced in continuous lengths, and the process or operation is continuous as long as the stream of metal flows.

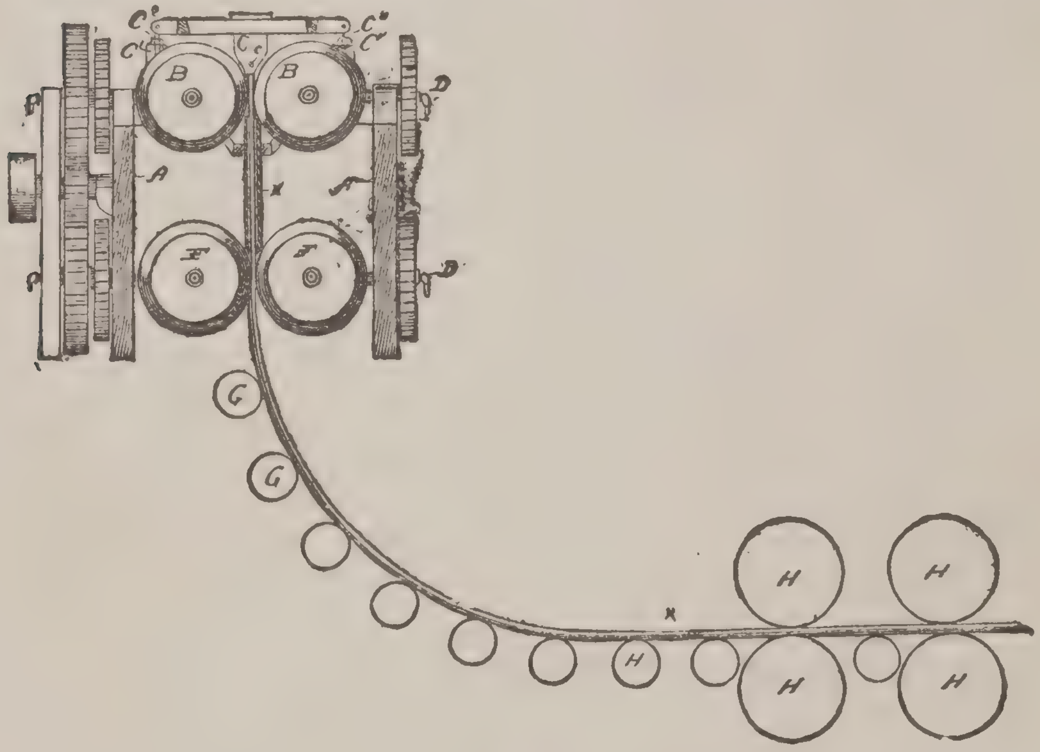


Fig. 67.

In the accompanying figure, *A* represents the frame of the machine, on which is journaled a series of rolls, *B*, preferably four in number, revolving together and having their peripheries shaped or grooved to form a passage or way between them to receive the stream of molten metal as it flows down from the pouring bowl or nozzle, *C*.

The working or meeting faces or peripheries of the rolls, *B*, are given a shape or configuration to form an ordinary railroad rail. They may, however, be shaped to give the space or passage any desired cross section, and thus produce a bar of any form required. The rolls, *B*,

have beveled faces, which meet or roll against each other and serve as stops for the several rolls against each other, so that the space or passage for the metal will always be maintained of a uniform size, and thus produce the rail or bar of a uniform cross section throughout. The rolls, *B*, are each made hollow and preferably with a central web, and the shafts are also made hollow, so that the water or other cooling fluid or liquid may be made to circulate through each of the rolls for the purpose of keeping them cool or of the desired temperature. The hollow shafts are each furnished with a packing or stuffing-box at each end, by which they are connected with the inlet and outlet water pipes, $D\ D^1$. The pouring bowl or vessel, *C*, is supported by any suitable means above the rolls, *B*, during the pouring operation, preferably by standards, C^1, furnished with adjusting screws, C^2. The pouring nozzle, *C*, is preferably furnished with a valve or device for opening and closing the discharge passage. The hollow shafts of the rolls are all geared together, so that they revolve or roll together at the same surface speed. The gearing employed may be preferably bevel gears, such as indicated at B^3. Two of the shafts, B^2, are also geared together by spur gears B^4. *E* is the driving shaft, having a gear, E^1, which meshes with a gear E^2, on one of the shafts, B^2. The pouring bowl or nozzle, *C*, is furnished with a guide or shield, extending down to near the meeting point of the rolls. This is designed to prevent the metal from splattering at the beginning of the pouring operation. A greater or less number of rolls than four may be employed.

F represents a second series of rolls arranged, preferably, directly below the chilling rolls, *B*, and between which the bar, *x*, passes as it issues from the chilling rolls, *B*. Rolls *F* are preferably of the same form and construction as the rolls *B*, being hollow and having the same connections for passing water through them, so that they may operate as chilling rolls as well as to further roll, compress and finish the rail or bar produced.

G is a curved guide or conveyer consisting preferably of a series of rolls or idle pulley-wheels, arranged in a curved path to curve and guide the bar as it issues from the rolls, *F*, to the horizontal conveyer or series of rolls, *H*. Some of the rolls, *H*, are preferably driven and operate to further roll or straighten the rail or bar, as well as to convey it along or away. The curved guide, *G*, also affords some slack in the rail or bar between the chilling rolls and rolls *H H*, to compensate for difference in speed or slipping.

Improved Method of Welding.—It is well known that in order to weld iron in a durable manner its surface must be free from oxide, which formerly could only be effected with a welding heat of 2800° F. Such a high temperature is, however, injurious to the quality of the iron, and still more so to that of steel, so that many varieties of the latter could not be welded in this manner.

To overcome this difficulty pulverized borax is used, which, however, cannot be uniformly distributed over the surface of the iron. Lafitte now uses a gauze of very flexible wire, and applies the fluxing agent uniformly to both sides of the gauze, or also to paper. For small surfaces it frequently suffices to form a leaf from the agglomerated fluxing agent and filings. Instead of covering the two surfaces with powder the wire gauze, which consists of the same material as the substances to be welded, is placed between them and welded in. The welding takes place at a much lower temperature, and the fluxing agent

generally volatilizes while the wire gauze melts and unites with the surface.

Electric Welding.—This process, the invention of Prof. Elihu Thomson, is a new art; for, unlike the smith, who is confined to iron, steel, and platinum, it can weld any two pieces of the same metal or alloy, ranging from the most refractory metals to the alloy which fuses at 162° F. It will join dissimilar metals when the welding point of one is not too far in excess of the fusion point of the other.

The Apparatus.—The electricity is generated by one of two methods. In the direct system the dynamo is contained in the machine below the clamps, and the armature contains two windings; the one being a fine winding, which is in series with the field-magnet coils, and the other winding being merely a bar of copper in the form of a letter U, or less than a single coil. This bar being of a very low resistance, the maximum current is sufficient for welding purposes, and the terminals are connected directly with the copper clamps. Alternating currents are generated in this machine, and used for welding, in order to avoid commutators, which are necessary in direct-current machines. It should be remembered that in all dynamos the electricity is generated in alternate currents, and that these currents are in proper turn fed to brushes of opposite polarity, and thus rendered continuous. In an alternating-current dynamo the electricity is conducted from the armature to rings instead of to a commutator, and it is thus better suited for large currents, and some forms of the apparatus do not require rings, or any moving contacts. There is no electrical reason why an alternating current should be used except the convenience of its manipulation. In fact, the continuous current applied by secondary batteries has been used for this purpose.

Another form of apparatus, termed the indirect system, is more conveniently suited for large work, or in places where a number of welding machines are operated by the current from a single dynamo. The welding current is produced by conversion of the comparatively high-tension current by means of an inverted induction coil, termed a transformer. The primary circuit from the dynamo is conducted through many turns of fine wire around a soft iron ring, and upon this same ring is a single turn of a large copper bar, in which the welding current is produced by inductive effect. These currents receive 4,000 to 15,000 alternations per minute. The welding currents are not changed suddenly or by switches, as such manipulation would not be desirable or even practicable with the great currents used; but in the direct welding machine, a set of resistance coils is placed in the fine circuit which passes around the field magnets, and by interposing more or less of the resistance coils in this circuit, the strength of the magnets is diminished or increased, and the welding current altered accordingly.

With the indirect machine, the amount of the secondary or welding current is controlled by varying the current in the primary coil by means of a kicking coil, or by a variable shunt to the field coil, and in other ways.

In either case the apparatus is simple, and in full and complete control at will of the operator by movement of a lever, and this action controls the heat.

The Process.—In the electric welding process, the two pieces to be joined are secured in firm end contact by a pair of adjustable copper clamps, which are placed upon the top of the apparatus. An electric

current of large volume is passed through the pieces, and the contact between them being of less conductivity than the homogeneous metal, heating ensues at this place, as the juncture is brought to the proper temperature by the gradual motion of the regulating lever, and as the metal softens the clamps are pressed towards each other to insure a continuous metallic union across the bar.

The weld begins at the centre and proceeds radially towards the surface, as the temperature becomes greater than at the interior. The heating is further increased by the fact that the resistance of the hot metal is greater than that of cold metal.

The enormous electric currents used in this welding process sometimes reach 50,000 ampères, but with an electro-motive force of half a volt, and therefore not capable of giving any sensation to a person.

It would be injudicious to offer any premium upon ignorance, but the operation of electric welding is one of the simplest of mechanical processes, requiring but little skill on the part of the operator in comparison with that exact training of hand and eye and long experience necessary for ordinary welding. The operator must understand the color of the proper welding heat of the metal under treatment, but this is readily learned. The work is not manipulated during the process, except when it is desired to reduce the burr at the weld, and is at all times under observation, and its heat subject to entire control by means of a lever which graduates the strength of the current.

The dynamo generating the electricity is self-regulating, and requires no attention except for lubrication.

There is no unnecessary waste of fuel, the heating being local, and does not extend far from the weld; cotton-covered wire one-fourth of an inch in diameter can be welded without searing the insulation over three-fourths of an inch from the weld.

The time for making a weld varies from a fraction of a second to about two minutes, according to the work; although nothing over two inches diameter has yet been welded, but larger machines are in process of construction.

It is not necessary to provide power fully equal to the maximum demand, as the time is so short that the momentum of a flywheel will serve the same purpose as in a drop press, and give up the surplus energy required.

The power is inversely proportional to the time, and appears to be about proportional to 2.3 power of the diameter in inches, with a slight variation of quick work caused by differences in the rates of the thermal conductivity of the material.

Applications.—The process is far cheaper than that of hand welding, and also extends to other methods of manufacture, but the comparative expense differs according to the previous conditions in every place where it has thus far been applied.

Its applications in practical work thus far have been chiefly confined to butt-welding for many purposes, such as continuous wire work, carriage work, axles and tires, cotton bale ties, barrel hoops and wire cables and many miscellaneous purposes. Axes are made of drop forgings, joining the tool steel edge to a mild steel poll; bars are heated in the middle and upset, forming collars, and pipes are joined together—a matter of great value in ice machines. The list might be continued to greater length, but this indicates the range of its practical uses at this early day.

Strength of Electric Welds.—The value of the process, for most purposes, independent of any scientific interest or mechanical ingenuity shown in the apparatus, must be that of the resistance of the welds under tensile stress.

It will be readily understood, however, that as this process accomplishes many things hitherto impossible, aside from any question of ultimate strength, it is fitted for applications in many constructions where it saves labor and time, provided only that the joints be in all cases sufficiently good for the purpose for which the article is designed. A large field thus opens up in the execution of ornamental design in metal work, where it will supplant screws, rivets or solder for fastenings, and in other evident applications.

Under the name "electrohephestos" MM. de Bernados and Olszewsky have patented a new method of electrically welding metals, especially parts of iron. This method, according to "Dingler's Polytechnical Journal," is in a certain sense a complement of Prof. Thomson's process. While the latter brings the pieces of metal to be joined to a welding heat and unites them by the use of pressure, thus forming an actual weld, Bernados and Olszewsky melt the two metals at their juncture, whereby a soldering together is effected.

Extensive experiments with Bernados and Olszewsky's electric welding apparatus have recently been made at Tegel, near Berlin. The process is described as follows: The joint of the two metals which are to be welded together is connected with the negative pole of a dynamo or other source of supply, the positive pole of which is formed by a carbon pencil. Under the intense heat of the arc the most refractory metals melt almost instantaneously at their junction and fuse together. But the action is purely local, like that of a blow-pipe, and only those parts upon which the arc plays directly are attacked, the adjoining portions undergoing little change, and the fused mass solidifies and cools very quickly. The slightness of the chemical change produced by the action of the arc at the joint is shown by the appended table:

	Steel.		Iron.	
Composition of material.	Before welding.	After welding.	Before welding.	After welding.
Carbon	0.48	0.25	0.34	0.14
Silicon	0.04	......	......	......
Manganese	0.50	0.25	0.50	0.23
Sulphur	0.04	0.04	0.14	0.09
Phosphorus	0.08	0.07	0.12	0.11
Iron	98.86	99.30	98.90	99.43

The material requires little or no preparation. Even a pretty thick layer of oxide will be reduced and drop off, while smaller quantities of oxide unite to form a slag with the sandy clay frequently added as flux. This slag prevents the oxidation of the metals while cooling.

No other fluxes are required. The operations can also be carried on under water, although the gases and steam generated cause trouble. Nevertheless an apparatus has been constructed to facilitate such work by forcing the water away from the parts to be treated by means of compressed air. One of the chief advantages claimed for the new process appears to be that the arc is brought to the work, and not the work taken to the arc, which would mean transformers, crucibles or other apparatus. Size is hence a question of secondary importance, and unwieldy pieces may be dealt with, although for soldering work of the ordinary kind a special operating table is employed as more convenient.

In order to obtain the various strengths of current and E. M. F. necessary when operating upon pieces of different size storage batteries are employed which have been especially constructed for this purpose by M. de Bernados. The complete cell, Fig. 68, weighs 35 lbs. and contains nine lead plates, Fig. 69, all of the same kind, four of them positive and five negative, with 1½ square yards of total surface. Each plate consists of a frame cast of pure lead 6 by 7¾ inches surface and 0.2 inch thick. The interior of the frame is filled with strips of thin lead, alternately straight and corrugated, Figs. 70 and 71, soldered into their places; the latter strips are bent in such a manner as to facilitate upward currents in the liquid. The cells have an interior resistance of 0.002 ohm and give 2.5 volts when continually charged while at work. Fifty to seventy of these cells are joined in a battery; several batteries, three for instance, are grouped in parallel and are continually charged by a shunt dynamo. The diagram, Fig. 72, explains the ordinary connections. The shunt dynamo charges the fifty accumulator cells in series; a voltmeter and an ampèremeter are inserted at *V* and *A*. From the positive terminal of every fifth cell a wire leads to a plug switch-board *U*; from *U* the current passes through a variable resistance *W*, and from thence through a flexible cable to the carbon-holder *Z* and the carbon pencil *K*. The operator manipulates this carbon-holder *Z*, the metal to be fused placed upon the table *P* being joined directly to the negative terminal of the battery. By inserting the plug in the switch-board *U* the operator may obtain currents from five cells, and so on to ten times five cells. If considerable masses of metal are to be dealt with, currents of considerable strength are needed. These are obtained by grouping the batteries of certain sets of cells in parallel. Supposing the dynamo gives a current of 175 volts and 120 ampères, that there is a battery of seventy cells coupled in series and that it is desired to solder two boiler plates of ⅜ inch thickness. The carbon-holder is connected with the positive terminals of the fortieth cells of three groups. The carbon is allowed to touch for a fraction of a second, and is taken off immediately, so that between the plates and the carbon pencil an arc of a few millimetres length is formed. The iron melts like wax, but the action seems too powerful, the molten metal hissing and evaporating distinctly. In such a case one of the three parallel groups is cut out. Should the action then be too sluggish, one or more parallel groups is added. Sometimes the arc proves too small or extinguishes frequently; in such cases the number of cells in each group has to be increased.

The carbon holder (Fig. 73) resembles a pair of scissors, and consists of two copper bars having a round hole near the end, in which the pencil is held firmly, either by the friction of the parts or by means of a little wedge, as shown in the illustration.

One of the most important applications of the new process is for

Fig 68

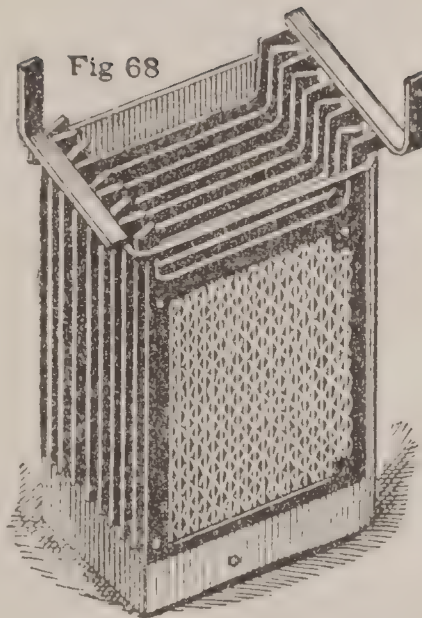


Fig 69

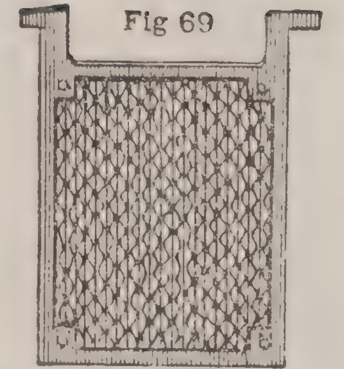


Fig 70

Fig 71

Fig 72

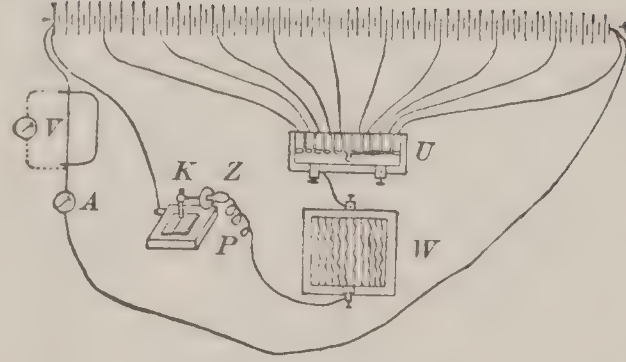


Fig 73

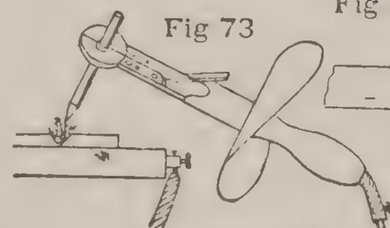


Fig 75

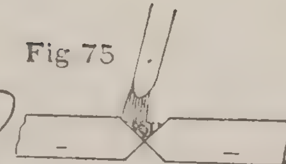


Fig 74

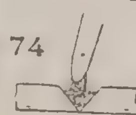


Fig 76

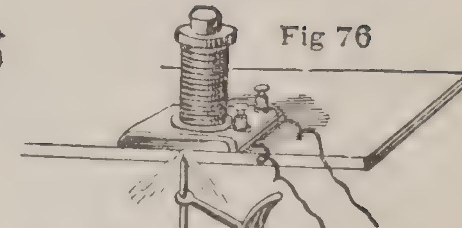


Fig 77

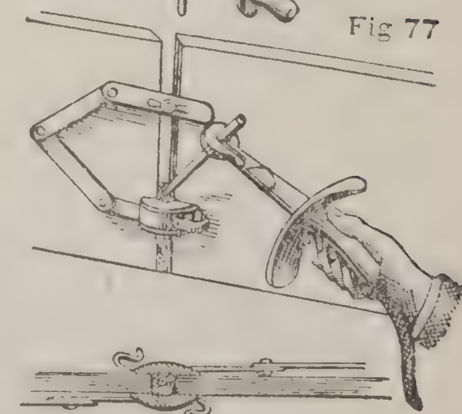


Fig 78

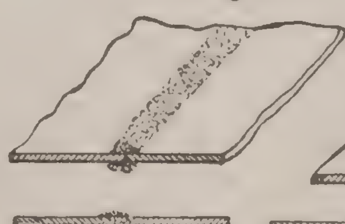


Fig 79

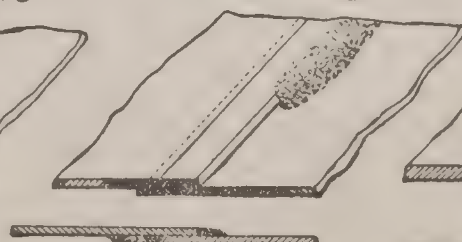


Fig 80

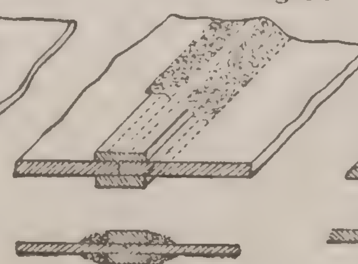


Fig 81

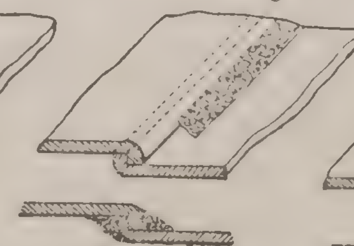
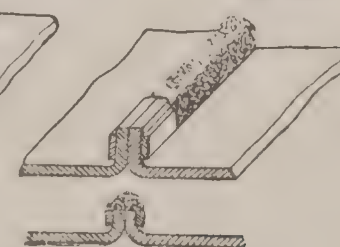


Fig 82



welding plates of all thicknesses. For the very finest sheets of 1 millimetre and less, the Electro-Hephestos Company prefer a modification of Prof. Thomson's process. But all stronger plates up to several centimetres thickness are subjected to the arc.

To effect this with ordinary plates, the edges are feathered as in Fig. 74, or Fig. 75, and pressed together. The furrows are filled with little pieces of the same material, and the arc is then applied, while fresh pieces are added until the furrow is completely filled with the molten mass. The plates are immediately afterwards finished under the hammer. In making iron welds the small pieces for filling are always of wrought-iron. With iron a flux of clay sand is recommended; with copper, borax or sal-ammoniac. The arrangement (Fig. 75) secures great strength, but is of course only applicable when the lower surface of the metal can be got at. When the plates are joined on their lower surfaces, M. de Bernados suggests a powerful electro-magnet placed as indicated in Fig. 76 to prevent the liquid metal (provided the material be para-magnetic) from flowing off. The apparatus shown in Fig. 77 looks more practical; it is intended to be employed when making vertical seams. The pincers S' and S'' carry two pieces of graphite or coke, C′ and C″, forming a sort of chamber at the spot where the fusion is to be carried on. As soon as the mass has hardened sufficiently the carbon pieces are pushed further up. Carbon pieces are frequently employed to prevent the flowing off of the fused material. Figs. 78 to 82 exemplify other ways of joining plates in cases where a perfectly straight surface is not insisted upon; for thinner plates the method, Fig. 16, seems to offer particular advantages; for two one-fifth-inch plates a seam of a yard length can be made in seven minutes. When plates are to be joined at an angle the process is, of course, exceedingly simple.

This process also permits of the welding of dissimilar metals, so that iron and copper, tin, zinc, steel, cast-iron, etc., can be united.

Manufacture of Wire.—Strong fine-grained iron produced in the finery process is best adapted for the manufacture of wire, but since the improvements in the puddling process puddled iron is likewise employed. The iron is first passed through wire-rolls. On account of the rapid cooling off to which the thin iron is exposed, the grooves of these rolls must stretch very powerfully, and, therefore, they are alter-

Fig. 83.

nately given the form of squares and ovals. Fig. 83 represents the entire series of grooves of a wire-roll. After each passage through the roll the iron is turned 90°. Fig. 84 shows the construction of an oval groove. The width of the groove b is the diagonal of a square, from the corners of which are described the two arcs which terminate the oval groove. Then is $b = 1.414\ r$, and $h = 0.5858\ r$.

In this manner the diameter of the iron is usually reduced to 4.5 to 6 millimetres (0.177 to 0.236 inch), and exceptionally even to 2 millimetres (0.079 inch). In the latter case the product is frequently directly used under the name of rolled wire.

The rolls have a length of 0.4 to 0.6 metre (1.31 to 1.96 feet), a diameter of 0.2 to 0.3 meter (0.65 to 0.98 foot), and make at least 100 revolutions per minute, though sometimes 220 to 250 and even 300 to 500. Three or six pairs of rolls are generally arranged alongside of each other, the iron being usually in two or three grooves of the rolls at the same time. On coming from the last groove the wire rod is wound upon a reel and freed from adhering scale by pickling and scouring.

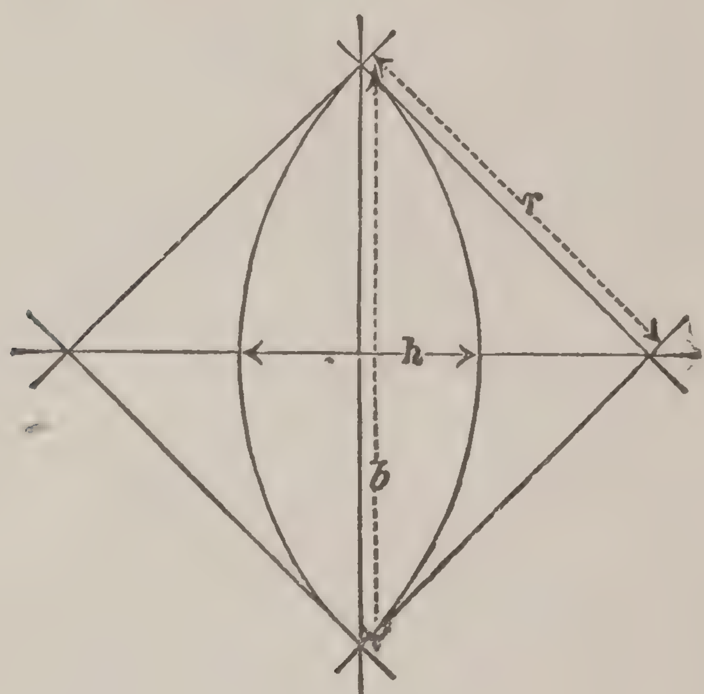


Fig. 84.

For the first purpose it is placed in heated dilute sulphuric acid (1 volume acid to 100 water), and for the latter, together with coarse sand and water, in a revolving drum.

The cleansed wire-rod is then drawn out to finer dimensions upon the draw-bench. The latter consists of a revolving drum, to which one pointed end of the wire is fastened after it has been passed through the corresponding groove of the draw-plate, which is a steeled iron plate provided with conical holes. By the revolution of the drum the wire-rod winding off from the reel is drawn through the draw-iron, reduced to the smallest diameter and correspondingly drawn out in length.

Fig. 85 represents a drawing mill; *A* being the reel, *B* the draw-iron, and *C* the drum. The reel around which the wire-rod or already drawn wire is spirally wrapped revolves freely in drawing. The draw-plate *b* is secured in a frame; the fine, hatched portion consists of steel. The drum is provided with a small plyer, into which is secured the end of the wire, drawn through the draw-plate by the hand. The shaft *f* with the disk *i* revolves constantly; the drum, however, stands still when empty. To set it again in motion it is lifted up by the treadle *f*, the hook *o* catching and carrying it along. When the wire *c*, which winds up spirally, has entirely passed through the

draw-plate, the tension ceases, and the drum falling from the hook *o* is liberated, and comes to a standstill without the assistance of the operator.

In consequence of the displacement of the iron crystals, the wire in drawing becomes hard and brittle, and, therefore, must from time to

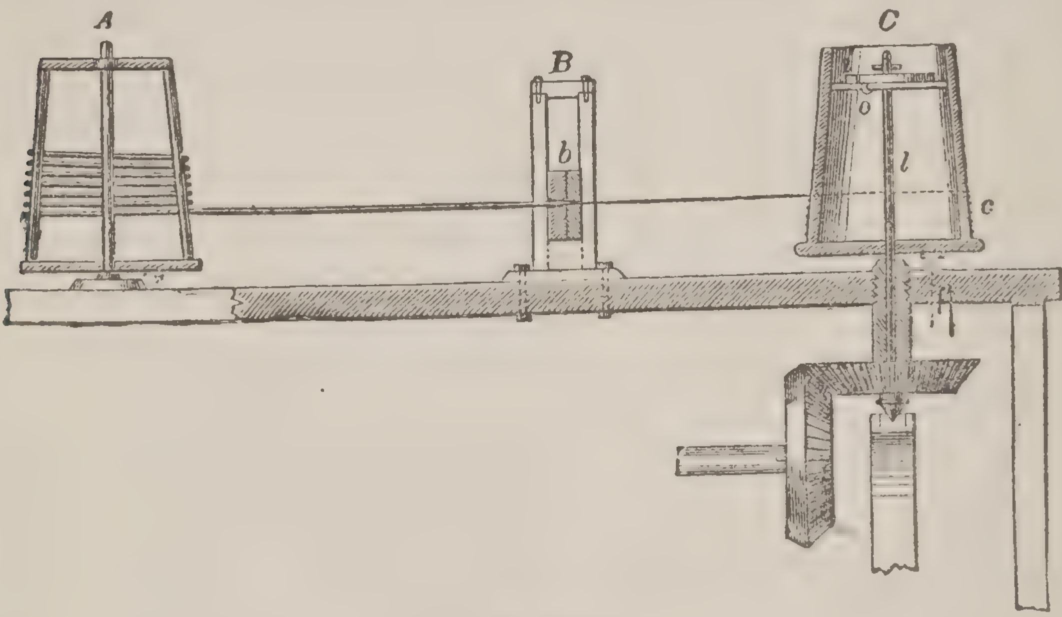


Fig. 85.

time be made ductile by annealing. This is done in iron pots, heated from the outside by a flame playing around them. Up to 1 millimetre diameter annealing usually takes place after every second or third draw; with thicker iron, however, after the second draw. With a height of 3 feet 3.37 inches and a diameter of 28.34 inches, an annealing pot holds 40 to 50 coils of wire.

Though the annealing pots are closed air-tight, the surface of wire is oxidized by the inclosed air and must be cleansed before again passing through the draw-plate. The ferrous oxide is removed by dilute sulphuric acid, and the wire after washing immersed in milk of lime, in order to neutralize any remnant of acid.

Before the final passage through the draw-plate, the wire is conducted through a slightly acid pickle of cupric sulphate (blue vitriol), consisting of 5 parts by weight of sulphuric acid, 3 of cupric sulphate, and 150 of water, whereby it acquires a bright copper-color surface, or, when the iron color is to be retained, through beer yeast, putrefying urine, or similar fluids which are sometimes covered with a layer of oil. Frequently the wire is also passed in front and behind the draw-plate over a sponge saturated with oil.

Sometimes the drum holding the wire runs in a paste of rape oil and flour slightly acidulated with sulphuric acid; repeated coppering is also frequently resorted to between the drawings.

For wire with figured cross-section, for instance, three-cornered, etc., a corresponding shape is given to the grooves of the draw-iron.

The loss by each annealing amounts to about 2 per cent. The product from 100 lbs. of welded iron amounts to 90 or 92 lbs. of rolled wire, and from 100 lbs. of rolled wire to 85 or 90 lbs. of drawn wire.

To succeed in drawing iron or steel wire, it is of the utmost importance to have thorough lubrication, as a lack of it would cause abrasion of the wire or of the walls of the tapering holes in the draw-plate, and quickly put an end to the operation.

In drawing coarse or large sizes of wire, say $\frac{2}{10}$ inch diameter, the pressure upon the sides of the tapering hole, where the wire comes in contact with the die, is so great that an ordinary lubricant is squeezed out when the usual reductions in size are made and abrasion takes place. In order to meet this difficulty, and secure proper lubrication, it has been a common practice for years to apply a paste made of rye or wheaten flour or lime to the surface of the wire to be drawn, and when the paste is dry to smear the wire with tallow or grease; the wire is then ready to be drawn, the dried paste serving to prevent the lubricant from being pressed out in the process. F. Vogel recommends the following preparation: Melt a certain quantity of lard or similar fat, and cool it off to 122° to 140° F. Then add, with constant stirring, 20 to 40 per cent. of 60 to 66 per cent. sulphuric acid until the mass has acquired the consistency of soft soap. Now add, with constant stirring, water, until the mixture is completely dissolved. By the addition of the sulphuric acid as well as of the water the mixture becomes again heated, and provision for sufficient cooling must therefore be made. The application of this preparation is claimed to allow of the wire being drawn through the draw-plate with such ease that it requires annealing once or twice less than when drawn by the ordinary method. It is further claimed that the draw-plates are subjected to less wear, and the wire acquires greater lustre and does not rust as readily.

Some years since, when Bessemer metal came largely into use as a material for wire, Charles H. Morgan, of Worcester, Mass., found that its drawing required so much more power than iron wire that he was led to institute a series of trials to ascertain the difference in power required. It was found that Bessemer wire required from 100 to 200 per cent. more power to make the same reduction in sizes than soft iron wire, the difference depending on the amount of carbon and other chemical constituents.

The failure of the coatings in common use in drawing Bessemer wire led to the inquiry: Is there not some coating that will endure this increased pressure? and trials were made at the works of the Washburn & Moen Manufacturing Company, at Worcester, Mass., to ascertain if something could not be found which, in combination of the flour or lime paste, would adhere with sufficient tenacity. While two young men were making, with discouraging results, trials of various substances to modify the lime coating, one of them said to the other: "If I wanted to make whitewash *stick*, I would put some salt in it; let us try it." Whereupon salt was used and found to make the whitewash stick, but it was also found that unless the wash was quickly dried on the wire and kept dry, the wire would be corroded with rust. Soon after it occurred to Mr. Charles H. Morgan to use a hot solution of lime and salt, and it was found that, by using the solution at a boiling temperature, the water was quickly thrown off when the wire was taken from the bath, and it was only necessary to keep the wire in a warm, dry place till it was drawn. Salt coating, whether combined with lime or otherwise, has been found to resist any pressure that steel wire of the highest tensile strength makes, when being drawn, upon the inner surface of the die.

TENACITY OF METALLIC WIRES AT VARIOUS TEMPERATURES.

METAL.	Diameter of wire at 61° F.	Sectional area.	Ultimate tensile strength.			Tensile strength per square inch.			
			At 32° F.	At 212° F.	At 392° F.	At 32° F.	At 212° F.	At 392° F.	
	inch.	sq. inch.	lbs.	lbs.	lbs.	tons.	tons.	tons.	
Gold	0.162	.000207	5.61	4.64	3.86	12.1	10.0	8.3	Maximum.
			5.42	4.49	3.80	11.7	9.7	8.2	Minimum.
Platinum	0.161	.000205	6.70	5.94	5.27	14.6	13.0	11.5	Maximum.
			6.59	5.61	5.03	14.4	12.2	11.0	Minimum.
Copper	0.177	.000247	10.11	8.80	7.92	18.3	16.0	14.4	Maximum.
			10.02	8.73	7.27	18.1	15.8	13.1	Minimum.
Silver	0.157	.000193	7.86	6.74	5.13	18.1	15.6	11.9	Maximum.
			7.78	6.39	5.10	18.0	14.8	11.8	Minimum.
Palladium	0.156	.000192	10.12	9.00	7.99	23.5	20.9	18.5	Maximum.
			9.98	8.89	7.41	23.1	20.6	17.2	Minimum.
Iron	0.069	.000373	11.12	10.66	11.31	133.2	127.6	135.4	Maximum.
			10.89	10.16	11.15	130.2	121.7	133.5	Minimum.

TENSILE STRENGTH OF WIRE-PHOSPHOR-BRONZE, COPPER, BRASS, STEEL AND IRON.

Description of Wire.	Unannealed.			Annealed.			
	Diameter.	Ultimate tensile strength.		Diameter.	Ultimate tensile strength.		Ultimate extension.
		Total.	Per square inch.		Total.	Per square inch.	
	inch.	lbs.	tons.	inch.	lbs.	tons.	p. c.
Phosphor-bronze.							
Lowest values	.0585 or $\frac{1}{17.1}$	....	43.59	.1070 or $\frac{1}{9.3}$	....	22.58	33.0
Highest values	.0665 or $\frac{1}{15}$	....	71.21	.1125 or $\frac{1}{9}$	....	28.82	46.6
Averages of 20 specimens	.063 or $\frac{1}{15.1}$	394	56.28	.1108 or $\frac{1}{9}$	527	24.42	39.0
Copper	.0640 or $\frac{1}{15.6}$	203	28.18	.0640 or $\frac{1}{15.6}$	119	16.52	34.1
Brass	.0605 or $\frac{1}{16.5}$	233	36.23	.0605 or $\frac{1}{16.5}$	148	23.01	36.5
Steel	.0600 or $\frac{1}{16.7}$	342	54.07	.0600 or $\frac{1}{16.7}$	211	33.32	10.9
Iron, galvanized B B C	.0580 or $\frac{1}{17.2}$	170	28.71	.0580 or $\frac{1}{17.2}$	162	27.36	17.1
do. do. B C I	.0580 or $\frac{1}{17.2}$	174	29.40	.0580 or $\frac{1}{17.2}$	122	20.61	28.0

COMPARATIVE TABLE OF WIRE GAUGES.

Number.	American Gauge.		Trenton Iron Company.		Rylands Bros. (English.)		New Standard of Great Britain.		Birmingham Wire Gauge.	
	Inch.	Weight. Per lin. ft.	Inch.	Weight.	Inch	Weight.	Inch.	Weight.	Inch.	Weight.
7–0	....	....	....	....	.5	.6446	.5	.661	....	....
6–0	....	....	....	....	.46875	.5666	.464	.569	....	....
5–0	....	....	.45	.536768	.4375	.4936	.432	.494	....	....
4–0	.46	.56074	.40	.424088	.40625	.4253	.4	.423	.454	.546207
3–0	.40964	.444683	.36	.343524	.375	.3626	.372	.366	.425	.478650
2–0	.3648	.352659	.33	.2886	.34375	.3046	.348	.320	.38	.38266
0	.32486	.279665	.305	.246487	.326	.2736	.324	.278	.34	.30634
1	.2893	.221789	.285	.215285	.3	.233	.3	.238	.3	.2385
2	.25763	.175888	.265	.186081	.274	.1936	.276	.202	.284	.213738
3	.22942	.13948	.245	.159083	.25	.1613	.252	.168	.259	.177705
4	.20431	.110616	.225	.134156	.229	.1353	.232	.142	.238	.150107
5	.18194	.08772	.205	.111408	.209	.1126	.212	.119	.22	.12826
6	.16202	.069565	.190	.095666	.191	.094	.192	.0976	.203	.109204
7	.14428	.055165	.175	.081155	.174	.078	.176	.0820	.18	.08586
8	.12849	.043751	.160	.06779	.159	.0653	.160	.0677	.165	.072146
9	.11443	.034699	.145	.0557	.146	.055	.144	.0548	.148	.058046
10	.10189	.027512	.130	.044776	.133	.0443	.128	.0434	.134	.047583
11	.090742	.02182	.1175	.036576	.117	.0353	.116	.0357	.12	.03816
12	.080808	.017304	.105	.029223	.10	.266	.804	.0286	.109	.031485
13	.071961	.013722	.0925	.02268	.09	.021	.092	.0224	.095	.023916
14	.064084	.010886	.080	.016973	.079	.016	.08	.0169	.083	.018256
15	.057068	.008631	.070	.012989	.069	.0123	.072	.0137	.072	.013728
16	.05082	.006845	.061	.009583	.0625	.0096	.064	.0108	.065	.011196
17	.045257	.005427	.0525	.00729	.053	.0073	.056	.00832	.058	.008915
18	.040303	.004304	.045	.005366	.047	.0056	.048	.00610	.049	.006363
19	.03589	.003413	.040	.004253	.041	.0043	.04	.00423	.042	.004675
20	.031961	.002708	.035	.003246	.036	.0033	.036	.00344	.035	.003246
21	.028462	.002047	.031	.0025457	.0315	.0026	.032	.00269	.032	.002714
22	.025347	.001703	.028	.0020779	.028	.002	.028	.00207	.028	.002078

COMPARATIVE TABLE OF WIRE GAUGES—*Continued.*

NUMBER.	American Gauge.		Trenton Iron Company.		Rylands Bros. (English.)		New Standard of Great Britain.		Birmingham Wire Gauge.	
	Inch.	Weight	Inch.	Weight.	Inch.	Weight	Inch.	Weight.	Inch.	Weight.
		Per lin. ft.								
23	.022571	.00135	.025	.001656			.024	.00152	.025	.001656
24	.0201	.001071	.0225	.001341			.022	.00128	.022	.001283
25	.0179	.0008491	.02	.00106			.02	.00106	.02	.00106
26	.01594	.0006734	.018	.0008585			.018	.000857	.018	.0008586
27	.014195	.000534	.017	.0007658			.0164	.000712	.016	.0006784
28	.012641	.0004235	.016	.0006838			.0148	.000579	.014	.0005194
29	.011257	.0003358	.015	.00059621			.0136	.000489	.013	.0004479
30	.010025	.0002663	.014	.00051939			.0124	.000408	.012	.0003816
31	.008928	.0002113	.013	.00044789			.0116	.000357	.01	.000265
32	.00795	.0001675	.012	.000381599			.0108	.000309	.009	.0002147
33	.00708	.0001328	.011	.00030457			.01	.000265	.008	.0001696
34	.006304	.0001053	.01	.000265			.0092	.000224	.007	.0001299
35	.005614	.00008366	.0095	.00023909			.0084	.000187	.005	.00006625
36	.005	.00006625	.009	.00021469			.0076	.000153	.004	.0000424
37	.004453	.00005255	.0085	.00019149			.0068	.000122		
38	.003965	.00004166	.008	.00016958			.006	.0000952		
39	.003531	.00003305	.0075	.0014871			.0052	.0000714		
40	.003144	.0000262	.007	.000129899			.0048	.0000608		
41							.0044	.0000513		
42							.004	.0000423		
43							.0036	.0000344		
44							.0032	.0000271		
45							.0028	.0000207		
46							.0024	.0000152		
47							.002	.0000106		
48							.0016	.0000068		
49							.0012	.0000038		
50							.001	.0000026		

How to Fish Wire.—Punch a hole through the plastering at the required position, being careful that there is no studding at that place. Use a brad awl and cut the hole large enough to set in the push-button plate. With a short length of small brass spring wire push through the opening a few inches of No. 19 double jack chain, such as is used for general fishing purposes, first having connected the end of the chain with a piece of heavy linen thread.

Run out the thread between the laths and outside wall until the chain touches the floor beneath; move the thread and locate the chain by the sound. Bore a hole through the base board or floor, as the case may be, toward the chain. Use a two or three-foot German twist gimlet. With a small brass spring wire, bent at the end in the shape of a hook, fish for the chain and draw it out.

At the other end of the thread attach the wire and draw it through with the thread. Passing under the floor, bore a second hole through the floor as near the other as possible. Run into this a piece of snake or fishing wire with a hook at the end until it comes to an obstruction. Locate the obstruction by sound.

In running wires under the flooring, first carefully examine all parts and find the direction in which the beams and timbers run, and run the wires parallel with these. After locating the ends of the fishing wire see if the obstruction is a timber; if so, find the centre and bore from the middle diagonally through it in the direction of the fishing wire.

Drop the jack-chain and thread through the hole, fish for it and draw it through hole No. 2, attach the insulated wire and draw it back. Starting at hole No. 3 bore hole No. 4 diagonally through the timber in the direction in which the wire is to be run, making holes No. 3 and 4 form an inverted V through the timber. Run the fishing wire through hole No. 4 until it meets an obstruction.

If at the end of the room, bore through the floor, drop the chain, fish it out, attach wire and draw it home. Putty up the holes after having done with them; or in case of hard finish, plug them up with wood. In lightly built houses it is often found easier to take off the molding above the base board and run the wire under it. In such cases care should be taken to break off the old nails, as any attempt to drive them out would cause a bad break.

In closets and around chimneys it is usually found easy to work. A mouse or lead-weight attached to a string may often be dropped from the attic to the cellar-ceiling through the space outside the chimney. It is well before starting on a job to carefully examine the whole house and find the easiest places to run in.

Sawing Stone by Helicoidal Wire Rope.—In place of the ordinary method of sawing stone, a new plan of cutting by means of wire-cord has been adopted. While retaining sand as the cutting agent, M. Panlin Gay, of Marseilles, has succeeded in applying it by mechanical means, and as continuously as the sand blast and band saw, with both of which appliances his system—that of the "helicoidal wire-cord"—has considerable analogy.

An engine puts in motion a continuous wire cord (varying from $\frac{5}{32}$ to $\frac{7}{32}$ inch in diameter, according to the work) composed of three mild steel wires twisted at a certain pitch, that found to give the best results in practice at a speed of 15 to 17 feet per second, the higher speed being adopted for the smaller diameter.

Instead of the stone being brought to the saw, the wire cord, which may be of indefinite length, is led to the stone, being guided by grooved pulleys, mounted on bearings with universal joint, which permits of their adapting themselves to any change of direction. The same cord, which is kept at uniform tension by a weighted truck on an inclined plane, may act upon any number of blocks, provided sufficient space be given them to allow for cooling.

The pulleys are mounted in standards, are fed down by endless screws rotated automatically if the stone be uniform, but preferably by hand if there is reason to suspect irregularities in its texture. Sand and water are allowed to flow freely into the cuts, the sand carried along by the cord in the spiral interstices between the wires causing a uniform attrition of the stone. The twist of the cord causes it, while travelling, to return upon itself, and thus become evenly worn. A cord of average length, say 150 yards, will cut about 70 feet deep in blocks 15 feet long, or produce 490 square feet of sawn surface before being worn out, when it may be used for fencing.

The sand must be sharp, and not used more than three times. The nature of the sand is determined by the hardness of the stone; thus quartz sand will cut granite and porphyry, which it has hitherto been found impossible to saw, or, indeed, cut in any other way than by pick and chisel. An hourly advance of 1 inch in granite or porphyry and 4 inches in marble is regularly obtained in blocks 15 or 16 feet long.

Not merely does the helicoidal cord saw blocks of stone, but it even cuts them out of the solid rock in the quarry. To do this, it is necessary to sink shafts of 2 feet or 2 feet 6 inches in diameter in order to introduce the pulley-carriers. If there be a free side to start from, one shaft is sufficient for a triangular block; but for a quadrangular one, which is preferable, two shafts are necessary. They are bored by a mechanical perforator, consisting of a hollow-plate iron cylinder, having at its lower end a slightly thicker collar, which acts with sand water in the latest development of the invention. The cylinder is made to revolve at a speed of 140 revolutions a minute, by means of a teledynamic cable, advancing in marble about an inch per hour. An annular space is cut in the rock, leaving a core which may be utilized as a column. The diameter of the shaftway depends upon the diameter of columns most in demand, provided a sufficient number be sunk, and the intervening angles broken down, so as to afford sufficient room for the pulley-carrier.

In the case of stratified rocks, the shaft-cuts are carried down to a natural parting; but in unstratified rocks, a nearly horizontal cut may be made with the cord, sufficient inclination being given to insure the flow of sand and water to the bottom of the cut.

The system is employed at granite and marble quarries in France, Germany, Spain, Italy, Algeria, Tunis, and other countries, where it is said to be giving satisfactory and economical results.

Hints for Preserving Tools.—The wooden parts of tools, such as stocks of planes and the handles of chisels, are often made to have a nice appearance by French polishing, but this adds nothing to their durability. A much better plan is to let them soak in linseed oil for a week, and then rub them with a cloth for a few minutes every day for a week or two. This produces a beautiful surface, and at the same time exerts a solidifying and preservative action on the wood.

Iron Parts.—*I. Rust Preventives.*—1. Caoutchouc oil is said to have proved efficient in preventing rust and to have been used by the German army. It only requires to be spread with a piece of flannel in a very thin layer over the metallic surface and allowed to dry up. Such coating will afford security against all atmospheric influences, and will not show any cracks under the microscope after a year's standing. To remove it, the article has simply to be treated with caoutchouc oil again, and washed after 12 to 24 hours.

2. A solution of India rubber in benzine has been used for years as a coating for steel, iron, and lead, and has been found a simple means of keeping them from oxidizing. It can easily be applied with a brush, and as easily rubbed off. It should be made about the consistency of cream.

3. All steel articles can be perfectly preserved from rust by putting a lump of freshly burnt lime in the drawer or case in which they are kept. If the things are to be moved, as a gun in its case, for instance, put the lime in a muslin bag. This is especially valuable for specimens of iron when fractured, for in a moderately dry place the lime will not need renewing for many years, as it is capable of absorbing a large amount of moisture. Articles in use should be placed in a box nearly filled with thoroughly slaked lime. Before using them rub well with a woolen rag.

4. The following mixture forms an excellent brown coating for preserving iron and steel from rust: Dissolve two parts of crystallized iron chloride, 2 antimony chloride, and 1 tannin in 4 of water, and apply with sponge or rag and let dry. Then another coat of paint is applied, and again another, if necessary, until the color becomes as dark as desired. When dry it is washed with water, allowed to dry again, and the surface polished with boiling linseed oil. The antimony chloride must be as nearly neutral as possible.

5. To keep tools from rusting, dissolve ½ oz. of camphor in 1 lb. melted lard; take off the scum, and mix in as much fine graphite as will give it an iron color. Clean the tools and smear with this mixture. After 24 hours rub clean with a soft linen cloth. The tools will keep clean for months under ordinary circumstances.

6. Put 1 quart freshly slaked lime, ½ lb. of soft soap in a bucket, and sufficient water to cover the articles; put in the tools as soon as possible after use, and wipe them next morning or let them remain until wanted.

7. Soft soap, with half its weight of pearl ash; 1 oz. of the mixture in 1 gallon boiling water is much in use in engineers' shops in the drip-cans used for turning long articles bright in wrought-iron and steel. The work, though constantly moist, does not rust, and bright nuts are immersed in it for days till wanted, and retain their polish.

8. Melt slowly together 6 or 8 ozs. of lard to 1 oz. resin, stirring until cool; when it is semi-fluid it is ready for use. If too thick, it may be further let down by coal-oil or benzine. Rubbed on bright surfaces never so thinly it preserves the polish effectually, and may be readily rubbed off.

9. To protect metal from oxidization—for instance, polished iron and steel—it is requisite to exclude the air and moisture from the actual metallic surface; therefore, polished tools are usually kept in wrappings of oil-cloth and brown paper, and thus protected they will preserve a spotless face for an unlimited time. When these metals come to be of necessity exposed, in being converted to use, it is necessary to

protect them by means of some permanent dressing, and boiled linseed oil, which forms a lasting covering, as it dries on, is one of the best preservatives, if not the best. But, in order to give it body, it should be thickened by the addition of some pigment, and the very best, because the most congenial pigment, is the ground oxide of the same metal; or, in plain words, rusted iron reduced to an impalpable powder, for the dressing of iron and steel, which thus forms the pigment of oxide paint.

10. Slake a piece of quicklime with just enough water to cause it to crumble in a covered pot, and, while hot, add tallow to it and work into a paste, and use this to cover over bright work; it can be easily wiped off.

11. Olmstead's varnish is made by melting 2 ozs. resin in 1 lb. of fresh, sweet lard, melting the resin first and then adding the lard and mixing thoroughly. This is applied to the metal, which should be warm, if possible, and perfectly clean; it is afterwards rubbed off. This has been well proved and tested for many years, and is particularly well suited for Danish and Russian iron surfaces, which a slight rust is apt to injure very seriously.

II. Rust Removers.—1. Cover the metal with sweet oil, well rub in, and allow to stand for 48 hours; smear with oil applied freely with a feather or a piece of cotton wool after rubbing the steel. Then rub with unslaked lime reduced to as fine a powder as possible.

2. Immerse the article to be cleansed for a few minutes, until all the dirt and rust are taken off, in a strong solution of potassium cyanide, say about ½ oz. in a wine-glass of water; take it out and clean it with a toothbrush, with some paste composed of potassium cyanide, castile soap, whiting, and water mixed into a paste of about the consistency of cream.

SOLDERS AND SOLDERING.

Composition of Solders.—An important particular in the preparation of solders is that they should be well stirred before pouring, preferably with a piece of green wood, and the surface of the molten metal exposed as little as possible to the air, so that dross (oxide) shall not form on the surface. A few knobs of charcoal on the molten metal will, to a very great extent, prevent the formation of dross.

Examining the soft solders in the following table, we see that plumbers' solder melts at 440° F., that is to say, at a lower melting point than the metal (lead pipe) for soldering which it is used. Further it is largely composed of lead. It thus fulfils both requirements of a good solder. Tinmen's solder melts at 320° F. It is used for soldering tin plate, which, remember, is iron coated with tin. Tin melts at 452° F., a higher temperature than that of its solder. Again the conditions of a good solder are fulfilled. Tinmen's solder is also used for soft soldering copper, because an alloy of lead and tin will readily coat copper, as also readily alloy with it.

Table of Solders.

Soft Solders.

	Lead.	Tin.	Melting p't. Fah.°	Uses.
Plumbers' solder....	2	1	440°	Joining lead pipe.
Coarse solder.........	3	1	482°	
Fine solder........ ...	1	2	340°	Blowpipe or gasfitters' solder, sometimes used by tinmen.
Fine solder............	1	1½	335°	First-class tinmen's solder; used also for soldering zinc and metal wheels, floats, etc., of wet gas meters.
Very fine solder.....	1	3	356°	
Very fusible solder.	1	1	320°	Ordinary tinmen's solder
Very fusible solder.	1	1	203°	Pewterers' solder.

Hard Solders.

	Copper	Zinc.	Silver.	Uses.
Spelter, hardest......	2	1	0	For iron work, gun-metal, etc.
Spelter, hard.........	1½	1	0	For copper and iron.
Spelter, soft....	1	1	0	For ordinary brass work.
Spelter, finer.........	2	2	0¼	For finer kinds of brass work.
Silver solder.........	1	0	4	Hardest, but makes very neat joints.
Silver, hard...........	1	0	1	Makes a sound joint and will not burn.
Silver, soft............	1	0	2	For general use.

Cold Solder.—An alloy useful when metals are to be soldered together at a low temperature can be made as follows: Copper in a fine state of division is obtained by precipitating with zinc from a solution of sulphate of copper. From 20 to 30 parts of this, according to the hardness required, are mixed in a cast-iron or porcelain mortar with concentrated sulphuric acid, to which is finally added 70 parts of mercury, and the whole triturated with the pestle. The amalgam thus formed is thoroughly washed with water to remove the sulphuric acid, after which it is left untouched for from 10 to 12 hours, at the end of which it is hard enough to scratch lead. To use the alloy for soldering

it is warmed till it is about the consistency of wax, and in this state it is applied to the joint, to which on cooling it adheres very firmly.

Soldering with Dry Lead Chloride.—The process consists in bringing the soldering plane of the heated soldering-iron in contact with the dry lead chloride. When the lead chloride is melted the solder is taken up in the usual manner and applied to the joints to be united. In this manner lead, zinc, copper, brass or iron can be readily soldered with lead with or without the use of soldering liquid. This interposing role of lead chloride for soldering purposes is also valuable for metallic coatings in a dry way by melting one metal upon the other. The articles to be coated are brought successively or simultaneously in contact with the melted lead chloride and the metal which is to furnish the coating. According to the shape of the article to be coated the melting may be effected either upon the article itself or the coating accomplished by dipping the object into the melted substances. Copper, brass and iron can in this manner be coated with zinc, tin and lead.

Soldering Cast-iron.—In a foundry doing agricultural work there are a great many alterations to be made to patterns, and often it is desirable to solder brass to cast-iron where drilling and rivetting to the pattern would make anything but a neat job. By a great many men who work on iron patterns it is considered quite a secret to solder on cast-iron, but it is not so. The process is very much the same as in soldering on a tinned surface. If the part of iron to be soldered is cast-iron that is hard and thin it should be polished on an emory-wheel and made clean and bright. Then dip it in potash water, after which dip it for an instant in clear water and wash it quickly with undiluted hydrochloric acid of the ordinary strength; go over it with powdered rosin and solder made from half tin and half lead. This must be done quickly before the surface has time to dry.

Another plan is this: File the surface clean and wash as before, wipe it over with a flux made of sheet zin dissolved in hydrochloric acid until it is surcharged, or is a saturated solution and has been diluted with its own quantity of water; then sprinkle powdered sal-ammoniac on it and heat it on a charcoal fire until the sal-ammoniac smokes. Dip it in melted tin, and then remove and rap off the surplus tin.

To Solder Cast-iron Objects.—Broken decorated cast-iron articles may be soldered by first removing the dirt from the surfaces to be joined and then brushing the latter with a brass scratch brush until they are, so to say, covered with a dry coat of brass. The surfaces thus covered with brass are then tinned in the same manner as brass and the parts soldered together in the usual manner.

Platinum Can be Made to Adhere to Gold by soldering in the following manner: A small quantity of fine or 18-carat gold should be sweated into the surface of the platinum at nearly a white heat, so that the gold shall soak into the face of the platinum. Ordinary solder will then adhere firmly to the face obtained in this manner.

Brazing with Brass or Copper.—File the parts to be joined clean, wire them in place or rivet them; then take a few lumps of borax and burn them on a piece of sheet-iron, then pulverize them, dissolve some on the article to be brazed in it, then lay on the piece of brass or copper,

tie it fast, sprinkle some of the borax over it, and put it in a clear fire, blowing very slow at first till the iron gets red. The appearance of a blue flame indicates the melting point of brass and copper. Allow the article to lie in the fire a minute without blowing, then take it out and lay it down gently on the hearth to cool. Very delicate articles should be dipped in a batter of clay to keep them from burning. When the clay begins to glaze it is time to take them out of the fire. Brass of copper should be brazed with silver. Copper can be brazed with brass, but the melting point of copper and brass are only a few degrees apart, and no such work is safe unless you have to deal with a large piece of copper. Brass and copper for brazing should be melted. When silver is used it should be old coin, or Mexican coin, such silver being purer. The blow-pipe is the best to braze with, but it requires some practice to use it successfully.

To Color Soft Solder.—The following method for coloring soft solder, so that when it is used for uniting brass the colors may be about the same, has been recommended. In making the solutions care should be taken to use glass or earthen dishes: First prepare a saturated solution (all that can be dissolved) of sulphate of copper or bluestone in water, and apply some of this on the end of a stick or small brush to the solder. On touching it then with an iron or steel wire it becomes coppered, and by repeating the experiment the deposit may be made thicker and darker. To give the solder a yellow color, mix in part of a saturated solution of zinc with two of sulphate of copper; apply this to the coppered spot, and rub with a zinc rod. The color may be still improved by applying gilt powder, and polishing. On gold jewelry or colored gold the solder is first covered as above; then a thin coat of gum or isinglass solution is laid on, and bronze powder dusted over it, making a surface which can be polished smooth and brilliant when the gum is dry.

To Remove Tarnish from Gold after Hard Soldering.—First protect your gold by painting it over with yellow ochre ground up with water and a very little borax. After soldering, throw into a pickle composed of water 6 parts, sulphuric acid 1 part. A copper boiling dish can be used for this pickle. If the article on coming out of this pickle is whitish-looking and shows too much of the silver alloy, dip for a moment in a hot mixture of sulphuric acid and saltpetre (no water). Wash and polish with rotten-stone and oil—then wash again and polish with rouge.

Gold Paint to Conceal Soft Solder.—Dissolve bleached shellac in alcohol, and mix the solution with best gold (brass) bronze powder. Apply like a paint with a small pencil brush.

MISCELLANEOUS.

India Ink, and How it is Made.—This product has no connection with India, and, as a matter of fact, ought to be called Chinese ink, it having been invented in China thousands of years ago. It was first made of lac, which is a resinous substance deposited by a small insect, and largely used in the manufacture of shellac. Afterward a peculiar black stone was found which could be dissolved in water, and later on

lac and fir wood were burned, and the resulting smoke gathered on some hard substance, scraped off and rolled into balls.

The process now employed by the Chinamen in the manufacture of their India ink is not radically different from that in use in ancient days. The old principle that burning resinous material will throw off thick smoke in large quantities is employed, only the smoke thus obtained is a little more scientifically handled. In the middle of a porcelain dish, about 2 feet in diameter and 3 or 4 inches deep, they place a stand about 6 inches in diameter and the same height as the dish. Several small lamps rest upon the stand, and by means of arms fastened to the sides of the dish small conical dishes are held just over the lamps. The dish is filled with water almost up to the tops of the lamp wicks, and the lamps are lighted. The smoke condenses on the conical dishes hung over the lamps, and is collected in the form of a dense black powder. This powder is placed in a vase, and a warmed mixture of 9 parts of fish glue and 1 part of animal glue strained into it through a piece of silk held over the mouth of the vase; the contents of the vase then being thoroughly stirred are rolled into balls, wrapped in cloth and immersed in hot water.

Kneading, another immersion, and beating with a hammer follow, the paste is scented, and in the form of long sticks is placed in various-shaped moulds. Wrapped in paper, the sticks are placed in a dish filled with rice-straw ashes, and in a day or two are thoroughly dried. Rubbing with cloths and brushes serves to clean and polish them, and they are then ready for the market. The soft paste can of course be moulded in any shape, but as a rule it is made into short, slender sticks, which are generally ornamented with Chinese designs. The peculiar qualities of the ink render it indispensable to sketch artists and draughtsmen, and nothing has been found to take its place.

Fixing India Ink.—India ink is excellent for plans and drawings until any color "wash," or even a little dampness, comes near the lines, when they then either "blur" or "run" all together. This may be prevented by dissolving in the water used for rubbing up the ink about 8 grains of bichromate of potassium, or 6½ grains of the corresponding ammonium salt per fluid ounce.

Manufacture of Smokeless and Flameless Powder.—Charles F. Hengst, of Plumstead, England, has taken out a patent for his invention, and describes the manufacture of the powder as follows: Straw, preferably oat straw, since it contains less silicic acid and other injurious substances than other similar organic substances, is in a similar manner as in the fabrication of paper converted into a pasty mass, which is then completely dried. This straw-mass is then treated with a mixture of 2 parts by weight of sulphuric acid of 1.85 specific gravity or 66° Be., and 1 of nitric acid of specific gravity 1.486 or 46° Be. A very high temperature being formed in the preparation of this mixture, it is allowed to rest for about 5 or 6 hours until the chemical reaction is past and the mixture cool. The straw-stuff is then placed in the mixture of acids, and the whole allowed to stand 35 to 45 hours, the light being excluded. The acids are then drawn off, and the straw-stuff is continuously washed in running water for about two hours. It is then brought into a vessel of sufficient size to allow of dilution, and boiled with water for 2 hours in order to free it from acid, the water lost by evaporation being constantly replaced. The mass is then freed

from water, preferably by pressing, and returned to the vessel which has been emptied in the meanwhile. Upon the mass is now poured a 1¼ per cent. aqueous solution of carbonate of soda or potash at about 177° F., and after thoroughly stirring with a glass rod the whole is allowed to cool about 2 hours. The fluid is then again drawn off, and the mass treated in a bath containing for 1,000 quarts of water about 47.5 lbs. of potassium nitrate, 7 lbs. of potassium chlorate, and 47.5 lbs. of potassium permanganate. The solution being brought to the boiling point, the straw-stuff is placed in it, and allowed to remain 2 to 6 hours, according to whether a slow or quick combustion in the use of the powder for firearms, cannon, etc., is desired. The mass thus treated is then freed as much as possible from water by pressing, pulverized with the assistance of a rapidly revolving contrivance and granulated in a suitable manner. The formed mass is finally dried with hot or dry air.

The gunpowder thus prepared can only be exploded by fire, flame, spark, or red heat. Its preparation is connected with no danger, and neither its transport, packing, or storing. When used there is no recoil, it produces no flame visible by night nor smoke visible by day, and the arms do not require washing or cleaning.

Preservation of Ropes.—Dip the dry ropes into a bath containing 20 grains of sulphate of copper per quart of water, and after allowing them to lie in soak in this solution for four days, dry them. The ropes will thus have absorbed a certain quantity of sulphate of copper, which will preserve them alike from rot and from the attacks of animal parasites. The copper salt may be fixed in the fibre by a coating of tar or by soapy water. In tarring the rope it is said to be better to pass it through a bath of boiled tar, hot, drawing it through a thimble to press back the excess of tar, and suspending it afterwards on a staging to dry and harden. According to another process the rope is soaked in a solution of 100 grains of soap per quart of water; the copper soap thus formed in the fibre of the rope preserves it from rot even better than the tar, which acts mechanically to imprison the sulphate of copper which is the real preservative.

Detonating Composition for Electrical Fuses.—The following two compositions are neither complicated nor difficult to prepare. They are very sensitive to the smallest electrical spark:

The first consists of a mixture of pulverized potassium chlorate and lead ferrocyanate. This mixture, when placed between two wire-points nearly touching each other, detonates immediately from a small electrical spark. Its preparation is very simple. The lead ferrocyanate is obtained by precipitating a soluble lead salt (acetate or nitrate of lead) with yellow prussiate of potash (potassium ferrocyanide) and thoroughly washing and drying the precipitate. The detonating composition is then obtained by mixing by means of a feather equal portions of finely pulverized potassium chlorate and of the precipitate.

A still more sensitive and very energetically exploding composition is obtained by mixing equal parts of potassium chlorate and lead sulphocyanate. It is prepared as follows: A soluble lead salt (acetate of lead, etc.) is precipitated with a solution of potassium sulphocyanate. The precipitate is collected upon a filter, washed and thoroughly dried. After being rubbed to a fine powder it is mixed by means of a feather with equal parts of potassium chlorate. The composition does not

undergo a change by being kept for some time; it is not hygroscopic, and spontaneous combustion need not be feared.

Imitation Frost Crystals.—A very pretty winter ornament for a parlor table, or to set on the showcase in the store, can be prepared as follows: Dissolve 456 grains of nitrate of lead in 6 fluid ounces of water. If the solution is turbid, filter through paper. Place the solution in a vessel on the table where it is intended to remain, and drop into it 200 grains of sal-ammoniac in long fibrous crystals. Small crystals of chloride of lead form and ascend through the denser liquid, presenting the appearance of an ascending snow storm. When the lead is all precipitated the crystals of chloride of lead begin to descend as a genuine miniature snow storm, forming grotesque masses resembling a winter's landscape. If the vessel containing the crystals is not disturbed it often preserves its beauty for a week or two.

Hectograph Paper Sheets.—Soak 4 parts of best white glue in a mixture of 5 parts of water and 3 parts of solution of ammonia until the glue is soft. Warm the mixture until the glue is dissolved, and add 3 parts of granulated sugar and 8 parts of glycerine, stirring well, and letting come to the boiling point. While hot, paint it upon white blotting paper with a broad copying brush until the paper is thoroughly soaked, and a thin coating remains on the surface. Allow it to dry for 2 or 3 days and it is then ready for use. An aniline ink should be used for writing, and, before transferring to the blotting paper, wet the latter with a damped sponge and allow it to stand one or two minutes. Then proceed to make copies in the ordinary way. If the sheets are laid aside for two days, the old writing sinks in and does not require to be washed off.

Rust-proof Wrapping Paper.—A new way of preparing paper for wrapping metallic articles to prevent tarnishing consists in incorporating with the paper or applying to its surface a fine powder of metallic zinc, in such a manner that it will adhere, so that when silver, copper, brass or iron articles are wrapped in the paper they will be preserved from rusting or tarnishing by reason of the mere affinity of the zinc for sulphuretted hydrogen, chlorine or acid gases or vapors, and preventing them from rusting or tarnishing the metallic articles wrapped in such paper. This is done by sifting on the sheet of paper pulp, while it is in the process of manufacture, and before it is pressed and dried, a metallic zinc powder, known in commerce as blue powder, in convenient quantity, about to the extent of one-half the weight of the dried paper. The paper is then run between the press-rolls and over the drying cylinders in the ordinary way. The zinc powder will adhere to the paper and be partly incorporated with it in greater or less quantity, as the sheet of paper pulp is more or less thick, or more or less wet. The paper may also be sized with glue or starch and then dusted with the zinc powder, or the zinc powder may be mixed with the size or starch, and then applied to the surface of the paper.

Preparation of Water-proof Packing Paper.—Dip the paper into the following mixture: White soap, 1½ lbs. dissolved in water, 1 quart; gum arabic, 4 ozs. 6 drachms; and glue, 13 ozs. 3 drachms dissolved in an additional quart of water. Both solutions are mixed

warm. After dipping the paper, press off the superfluous fluid and dry at a moderate heat.

Water-proof Paper.—Paper treated with a mixture of camphor oil and linseed oil becomes water-proof.

Paper that Resists the Action of both Fire and Water, it is said, has been recently invented in Germany. The manufacture is accomplished by mixing 25 parts of asbestos fibre with 2 to 30 parts of aluminium sulphate. This mixture is moistened with chloride of zinc and thoroughly washed with water. It is then treated with a solution of 1 part of resin soap in 8 or 10 parts of a solution of pure aluminium sulphate, after which it is manufactured into paper, as is done from ordinary pulp.

To take Creases out of Drawing Paper or Drawings, lay the drawing face downwards on a sheet of smooth white paper, then cover it with another sheet slightly dampened, and iron with a moderately warm flat-iron. Engravings that are creased may be treated in the same manner.

Marking on Blue Prints.—It is well known to everybody acquainted with machine shop practice that frequent changes, more or less extensive, must be made on drawings by which any machine may be constructed. When blue prints are used, as they are in all shops of any note, such changes have been difficult, or at least unsatisfactory, whenever the marking agents used were black ink, alkalies, or Chinese white. Black on the blue ground does not give a sufficient contrast to be easily read. Alkalies, though giving at first a somewhat white line, in a short time fade more or less, leaving a yellowish dirty mark, which neither looks well nor is easily read. The use of Chinese white is objectionable because it is not permanent—it is easily rubbed off unless fixed by varnish. But to varnish blue prints is poor economy.

The most satisfactory marking ink for blue prints is the *red soda*. This consists simply of a red ink, in which a little gum arabic and enough soda has been dissolved to decompose the blue coloring matter of the print. The relative amount of each is usually determined by trial. Red ink alone does not show much better on a blue print than black ink. The action of the soda solution alone is to decompose the blue matter of the print and leave the white paper exposed. This "white paper" is colored at the same time to any color desired, if the proper coloring matter be added to the clear soda solution. Diamond dyes answer admirably for this purpose. The gum arabic solution is added to thicken the soda solution, to prevent it from flowing too freely from the pen and spreading on the paper which it is otherwise liable to do. Caustic soda is the best for the purpose; ordinary washing soda, however, will answer.

A red ink thus prepared makes a bright contrast with the blue background of the print, and looks well. Any small alteration of a drawing may be drawn on the print with this ink without erasing the original lines, which can never be done well, and still the drawing is easily read, because the red lines are so prominent that they are not obscured in the least by the original lines. Of course, no extensive changes are made in this way, the blue print being replaced by a

new one, made from the corrected "original," when it is cheaper to do so.

Any marking may be done on a blue print with this ink without the necessity of leaving a "white spot" to mark on, and then the red shows even better than the black on white.

Scouring and Bleaching Feathers.—Scouring and bleaching are two distinct operations, the former tending to remove from the material all fatty substances, while the latter consists in rendering the feathers perfectly white, after having been cleansed from their fatty contents. According to quality, the first washing in soap is done at 100° to 122° F., the bath to be prepared in the proportion of 500 parts by weight of white Marseilles soap for 600 of water, and well beaten up into a lather. Lay down the feathers and rub them well by hand until the bath is exhausted and has lost its detergent power. Then let it out and repeat the operation with a fresh bath of the same composition; then remove the soap by rinsing in 2 or 3 waters at 100° F. Prepare a cold bath of 45 to 62 grains of bioxalate of potash to 5 quarts of water, lay down the feathers for 15 or 20 minutes, lift and rinse in cold water. After passing them 3 or 4 times through the cold water, the feathers are to be blued. For this purpose add to a fresh bath of cold water so much solution of (methyl) aniline violet as will give the water a faint tint; open the feathers well and agitate them in the bath until they also have assumed the tint; then squeeze them out in a clean white piece of cloth (muslin) and pass through a pretty thick solution of raw starch (8 ozs. to 4 quarts water unboiled), squeeze out again, open them by passing the hand lightly over the stem, and dry either in a warm place, or preferably in the air, shaking them repeatedly while drying in order to perfectly open the fibres. Finally beat out the remaining starch either by hand or by means of a soft brush.

To Color Moss.—Moss intended for wreaths and bouquets or for similar purposes is generally colored in dark and light shades of green, brown, violet and black, and some white or bleached varieties, red. The moss is first cleaned, thoroughly dried and tied in loose bundles. The latter, with the head-end of the moss outwards, are placed in wide-meshed nets, which are immersed in the color. As soon as the moss has acquired the desired shade it is taken out, pressed and dried, without, however, rinsing it previously in water.

Dark green is produced with malachite green. Dissolve in 1 quart of water 2.82 drachms of alum, heat the mixture to 189° F., and add malachite green until the color has a beautiful blue-green appearance. By adding to the color some picric acid, the moss acquires a pale yellow color, while a yellow green is produced with yellowish methyl green and a sufficient addition of picric acid. A brown red color is given to the moss by aniline fuchsine, the process being the same as for green. Dark violet is obtained by methyl violet, it being, however, best to use for this and the last color moss bleached in the sun.

The moss is colored black by mixing 2.25 drachms of dissolved logwood extract with 1 quart of water, and putting the moss in the mixture for 3 to 4 hours so that it is entirely covered. Then mix 2.25 drachms of blue vitriol with 1 quart of cold water, take the moss from the logwood decoction, and after pressing it well out put it into the

solution of blue vitriol, allowing it to remain 4 to 6 hours. Now add to the logwood decoction a small quantity of whiting and a few grains of potassium bichromate, and after pressing out the moss place it in the solution and allow it to remain until it is black. Then press out and dry it in the shade, without, however, rinsing it in water.

Rose-color can only be produced upon very pale moss or upon completely bleached varieties. It is produced by adding as much safranine to a mixture of 5.64 drachms of alum in 1 quart of water as is necessary to produce the desired shade.

Red is obtained by heating 8.46 drachms of alum in 1 quart of water to the boiling point, then adding the necessary quantity of easine and allowing the moss to remain immersed in the boiling fluid for several minutes.

Cleaning Oil.—To clean lubricating oil that has once been used so that it can be used again, pour it gently over a bed of iron which is strongly magnetized. The heaps of iron fragments constitute a magnetic sponge which stops all the particles of metal, especially those of iron. The oil is then passed through two hair filters and comes out perfectly clean.

Making Tissues Brilliant.—A new method for giving brilliancy to printed tissues consists in the properties of hydrate of farina (potato starch) to form a kind of soap with the fatty matters. Dissolve ¼ lb. of potato starch in 16 ozs. of river water. Heat the solution slowly, stirring it continually with a wooden spoon, until it congeals to a weak consistency. Then mix it with 17 pints of tepid water in an earthenware vessel, the result being a water which is sweet, glutinous and sharp to the touch.

Ink Eraser.—Blotting paper or a similar material is immersed in a hot concentrated solution of citric acid, then rolled into a pencil and the larger portion of it coated with paper or lacquer. For use the eraser is moistened with the tongue or water and rubbed over the ink to be removed. A drop of water containing chloride of lime is then dropped upon the ink spot, whereby the ink immediately disappears.

Absolute Alcohol Obtained Without Distillation.—If gelatine be suspended in ordinary alcohol it will absorb the water, but as it is insoluble in alcohol that substance will remain behind, and thus nearly absolute alcohol may be obtained without distillation.

Cheap Jacketing for Steam-pipes.—Wrap the pipe in asbestos paper, and lay a number of strips of wood lengthwise, from six to twelve, according to the size of the pipe, and bind them into position with wire; around the frame work thus constructed wrap roofing paper, fastening it with paste or twine. If exposed to the weather, use tar paper or paint the outside.

Renovating Picture Frames.—Dingy or rusty gilt picture frames may be improved by simply washing them with a small sponge moistened with spirits of wine or oil of turpentine, the sponge only to be sufficiently wet to take off the dirt and fly marks. They should not be wiped afterward, but left to dry of themselves.

Liquid Stove Polish.—Mix 2 parts of copperas, 1 of bone black, 1 of pulverized graphite, with sufficient water to form a creamy paste. This stove polish is as nearly odorless as possible.

Test for the Quality of Leather.—A handy test for the quality of leather is to allow small pieces to remain for several hours in vinegar. If the leather has been well tanned the vinegar will only darken the color; if, on the contrary, the leather is of poor make, it will partly or wholly form a gelatinous mass.

How to Polish Sea Shells.—The outer and rougher portions are usually eaten off with some of the stronger acids, like sulphuric or muriatic, the inner surfaces being protected with tallow or wax. Rough grained stones, followed by finer ones, smooth the surface, and finally ground pumice stone and water with a wood wheel to remove scratches. This course makes the harder sea shells smooth, and a coat of spirit varnish (bleached shellac dissolved in methylic alcohol) gives the look of polish. A real polish requires a good deal of labor, and is obtained by using tripoli and water, or putty powder (oxide of tin) and water, and such buffs as the form or parts of a shell demand.

Incombustible Wick.—Fine wood sawdust 4 parts; powdered fire clay 2 parts; powdered glass 1 part; cotton or cotton dust 1 part; sea-sand 6 parts. This mixture moistened, dried and fired at a full red heat for half an hour, is stated to yield a very permanent and porous material for lamp wicks.

Glycerine, Some of its Practical Uses.—As a dressing for ladies' shoes it renders the leather soft and pliable without soiling garments which come in contact.

For excessive perspiration of the feet, 1 part of burnt alum with 2 of glycerine should be rubbed on the feet at night and a light, open sock worn. In the morning the feet should be washed with tepid water.

For bunions and corns, equal parts of cannabis indica and glycerine should be painted on the surface and covered with canton flannel.

For the face, oatmeal made into a paste with 2 parts of glycerine and 1 of water may be applied at night under a mask as a complexion improver.

As a supplement to a bath, 2 ozs. of glycerine in 2 quarts of water will render the skin fresh and delicate.

For coughs, one to two tablespoonfuls of glycerine in pure rye whiskey or hot rich cream will afford almost immediate relief.

For consumption, 1 part of powdered willow charcoal in 2 parts of glycerine is a panacea.

For diseased and inflamed gums, 3 parts of golden seal, 1 part of powdered burnt alum, and 2 parts of glycerine, rubbed on at night, after first removing any tartar.

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